

PART 700

MATERIALS

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ROCK, GRAVEL, AND SAND

701.1 GENERAL:

The following specifications set forth the requirements for crushed rock, gravel, sand, and quarry stone. Samplings and sieve analysis shall be performed in accordance with ASTM D-75 and ASTM C-136. Sand equivalents shall be determined in accordance with AASHTO T-176. The liquid limit and plasticity index shall be determined in accordance with AASHTO T-89 and T-90.

701.2 CRUSHED ROCK AND GRAVEL:

Rock and gravel shall be clean, hard, sound, durable, uniform in quality, and free of any detrimental quantity of soft, friable, thin elongated, or laminated pieces, disintegrated material, organic matter, oil, alkali, or other deleterious substance.

The loss by abrasion in the Los Angeles abrasion machine, determined as prescribed in ASTM C-131, Grading A, shall not exceed 10 percent, by weight, after 100 revolutions nor 40 percent after 500 revolutions.

701.2.1 Crushed Rock: Crushed rock shall consist of the product obtained by crushing rock, stone, or gravel so that at least 50 percent by weight of aggregate retained on the No. 4 sieve for 3/4 inch or larger maximum sizes, and 50 percent retained on the No. 8 sieve for maximum sizes less than 3/4 inch shall consist of particles which have at least one rough, angular surface produced by crushing. All material that will pass a grizzly with bars spaced 15 inches apart, clear opening, shall be crushed when producing from the Contracting Agency's source.

The gradation of crushed rock shall comply with ASTM D-448.

701.2.2 Gravel: Material designated herein as gravel shall be composed entirely of particles that are either fully or partially rounded and water-worn. Crushed rock obtained by crushing rock which exceeds ASTM D-448 maximum gradation sizes may be combined provided it is uniformly distributed throughout and blended with the gravel. The quality and gradation requirements shall be as stated in this specification.

701.3 SAND:

Sand shall be fine granular material produced by the crushing of rock or gravel or naturally produced by disintegration of rock and shall be sufficiently free of organic material, mica, loam, clay, and other deleterious substances to be thoroughly suitable for the purpose for which it is intended.

701.3.1 Sand for Asphalt Concrete Pavement: Sand for asphalt concrete pavement shall comply with AASHTO M-29 except that grading requirements shall be deleted and have a minimum sand equivalent of not less than 50 and shall be non-plastic when tested in accordance with AASHTO T-89 and T-90.

701.3.2 Sand for Portland Cement Concrete, Mortar and Plaster: It shall be thoroughly and uniformly washed and shall be entirely free from oil and deleterious substances.

The average value of sand equivalent determined on 3 successive samples shall not be less than 70. No individual sample shall have a sand equivalent less than 65.

The size and grading of sand to be used in cement concrete, mortar, and plaster shall be such as to conform with the requirements specified as follows:

Concrete:	ASTM C-33
Mortar:	ASTM C-144
Plaster:	ASTM C-35

701.3.3 Coarse Aggregate for Portland Cement Concrete: Coarse aggregate shall conform to ASTM C-33 grading size No. 467, 57, 67, and 7.

701.3.4 Aggregate for Masonry Grout: The size and grading of the fine or coarse aggregate to be used in masonry grout shall conform with ASTM C-404.

701.3.5 Aggregate for Controlled Low Strength Material: Coarse aggregate shall conform to ASTM C-33 grading size No. 57. The size and gradation of fine aggregates (sand) shall conform to ASTM C-33.

701.4 QUARRY STONE:

701.4.1 General: Quarry stone shall be angular, sound, durable, hard, resistant to abrasion; free from laminations, weak cleavages, and undesirable weathering, leaching, exfoliation tendencies, and slaking; and of such character that it will not disintegrate from the action of air, water, or the conditions to be met in handling and placing. Stone shall be clean and free from deleterious impurities, including alkali, earth, clay, refuse, and adherent coatings. Suitable tests and/or service records will be used to determine the acceptability of the stone. Tests to which the material may be subjected include petrographic analysis, X-ray diffraction, specific gravity, absorption, abrasion, rock drop, soundness, wetting and drying, and such other tests as may be considered necessary to demonstrate to the Engineer that the materials are acceptable for use in the work. In connection therewith, the Contractor shall notify the Engineer in writing at least 60 days prior to use of the intended sources of quarry stone.

701.4.2 Test Requirements: Quarry stone shall meet the following requirements except as may be otherwise provided on the plans and in the special provisions:

(A) Apparent specific gravity: 2.65 minimum.

(B) Breakdown:

Rock drop breakdown:	5 percent maximum
Abrasion breakdown at 1000 revolutions:	40 percent maximum
Breakdown after 10 cycles of wetting and drying:	5 percent maximum
Solubility in water, breakdown, or softening:	None

701.4.3 Test Methods: Unless otherwise specified in the special provisions or indicated on the plans, test methods for quarry stone shall be as follows:

(A) Apparent specific gravity per ASTM C-127.

(B) Abrasion characteristics to be determined by either Rock Drop Test or Los Angeles Rattler, ASTM C-131, as required on the plans or the special provisions.

(1) Standard Rock Drop Test. Tests shall be made on groups of 5 accurately weighed sizes of rocks: No. 1, ranging from 75 to 100 lbs.; No. 2, 100 to 125 lbs.; No. 3, 125 to 150 lbs.; No. 4, 150 to 175 lbs.; No. 5, 175 to 225 lbs.

Each rock of the 5 sizes shall be dropped 3 times on the group of the other 4, in an enclosure, from successive heights of 10, 15, and 18 feet. The enclosure shall have a flexible medium weight galvanized iron floor or equivalent, set on a solid foundation. Order of dropping shall be Nos. 3, 2, 4, 1, 5. All rock passing a 3 inch square mesh screen after test shall be weighed and recorded as a percentage of the total initial weight of the 5 rocks.

(2) Los Angeles abrasion machine, per ASTM C-131, Grading B.

ROCK, GRAVEL, AND SAND

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The loss by abrasion in the Los Angeles abrasion machine, determined as prescribed in ASTM C-131, Grading A, shall not exceed 10 percent, by weight, after 100 revolutions nor 40 percent after 500 revolutions.

701.2.1 Crushed Rock: Crushed rock shall consist of the product obtained by crushing rock, stone, or gravel so that at least 50 percent by weight of aggregate retained on the No. 4 sieve for 3/4 inch or larger maximum sizes, and 50 percent retained on the No. 8 sieve for maximum sizes less than 3/4 inch shall consist of particles which have at least one rough, angular surface produced by crushing. All material that will pass a grizzly with bars spaced 15 inches apart, clear opening, shall be crushed when producing from the Contracting Agency's source.

The gradation of crushed rock shall comply with ASTM D-448.

701.2.2 Gravel: Material designated herein as gravel shall be composed entirely of particles that are either fully or partially rounded and water-worn. Crushed rock obtained by crushing rock which exceeds ASTM D-448 maximum gradation sizes may be combined provided it is uniformly distributed throughout and blended with the gravel. The quality and gradation requirements shall be as stated in this specification.

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701.3.2 Sand for Portland Cement Concrete, Mortar and Plaster: It shall be thoroughly and uniformly washed and shall be entirely free from oil and deleterious substances.

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The size and grading of sand to be used in cement concrete, mortar, and plaster shall be such as to conform with the requirements specified as follows:

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701.3.5 Aggregate for Controlled Low Strength Material: Coarse aggregate shall conform to ASTM C-33 grading size No. 57. The size and gradation of fine aggregates (sand) shall conform to ASTM C-33.

701.4 QUARRY STONE:

701.4.1 General: Quarry stone shall be angular, sound, durable, hard, resistant to abrasion; free from laminations, weak cleavages, and undesirable weathering, leaching, exfoliation tendencies, and slaking; and of such character that it will not disintegrate from the action of air, water, or the conditions to be met in handling and placing. Stone shall be clean and free from deleterious impurities, including alkali, earth, clay, refuse, and adherent coatings. Suitable tests and/or service records will be used to determine the acceptability of the stone. Tests to which the material may be subjected include petrographic analysis, X-ray diffraction, specific gravity, absorption, abrasion, rock drop, soundness, wetting and drying, and such other tests as may be considered necessary to demonstrate to the Engineer that the materials are acceptable for use in the work. In connection therewith, the Contractor shall notify the Engineer in writing at least 60 days prior to use of the intended sources of quarry stone.

701.4.2 Test Requirements: Quarry stone shall meet the following requirements except as may be otherwise provided on the plans and in the special provisions:

(A) Apparent specific gravity: 2.65 minimum.

(B) Breakdown:

Rock drop breakdown:	5 percent maximum
Abrasion breakdown at 1000 revolutions:	40 percent maximum
Breakdown after 10 cycles of wetting and drying:	5 percent maximum
Solubility in water, breakdown, or softening:	None

701.4.3 Test Methods: Unless otherwise specified in the special provisions or indicated on the plans, test methods for quarry stone shall be as follows:

(A) Apparent specific gravity per ASTM C-127.

(B) Abrasion characteristics to be determined by either Rock Drop Test or Los Angeles Rattler, ASTM C-131, as required on the plans or the special provisions.

(1) Standard Rock Drop Test. Tests shall be made on groups of 5 accurately weighed sizes of rocks: No. 1, ranging from 75 to 100 lbs.; No. 2, 100 to 125 lbs.; No. 3, 125 to 150 lbs.; No. 4, 150 to 175 lbs.; No. 5, 175 to 225 lbs.

Each rock of the 5 sizes shall be dropped 3 times on the group of the other 4, in an enclosure, from successive heights of 10, 15, and 18 feet. The enclosure shall have a flexible medium weight galvanized iron floor or equivalent, set on a solid foundation. Order of dropping shall be Nos. 3, 2, 4, 1, 5. All rock passing a 3 inch square mesh screen after test shall be weighed and recorded as a percentage of the total initial weight of the 5 rocks.

(2) Los Angeles abrasion machine, per ASTM C-131, Grading B.

(C) Wetting and drying. The stone shall be crushed, screened, and 1000 or 1500 grams of the 3/4 inch to 3/8 inch fraction taken for the test.

The crushed and graded stone shall be submerged in water for 18 hours at room temperature, after which the sample shall be drained and oven-dried at 140°F. When dry, the sample shall be cooled to room temperature. This would complete one cycle.

The percent loss shall be determined by screening the tested sample on a No. 4 sieve and shall be computed as follows:

$$\frac{100 - \text{Weight of Material Passing No. 4 Sieve}}{\text{Total Weight of Sample}} = \% \text{ Loss}$$

(D) Accelerated water breakdown and solubility test. Air-dry samples of representative stone weighing approximately 1 lb. each shall be immersed for 8 hours at 140°F., in distilled water, local tap water, or 3.5 percent sodium chloride solution.

BASE MATERIALS

702.1 GENERAL:

Materials for use as aggregate base shall be classified in the order of preference as follows:

- (A) Crushed Aggregate.
- (B) Processed Natural Material.
- (C) Processed Steel Slag.
- (D) Decomposed Granite.

When base material without further qualification is specified, the Contractor shall supply crushed aggregate. When a particular classification of base material is specified, the Contractor may substitute any higher classification of base material for the specified classification.

Except where materials are being obtained from a previously approved source, the Contractor shall give the Engineer 10 days advance notice, in writing, of the source of the base material he intends to use in order to allow sufficient time to perform the necessary tests.

Municipality	Supplements
PH:	2.1 General: For all City of Phoenix projects, aggregate base or ABC as used on the plans and Standard Details shall be crushed aggregate, with gradation as for aggregate base per Table 702, and shall be placed in conformance with Section 310 for Untreated Base.

702.2 CRUSHED AGGREGATE:

Crushed aggregate shall consist of crushed rock or crushed gravel or a combination thereof as defined in Section 701.

702.2.1 Soundness: The percentage of wear of crushed aggregate to be used as base will be determined as in Section 701, except that Grading B of ASTM C-131 shall be used. The percentage of wear of the material shall not exceed 40 after 500 revolutions.

702.2.2. Grading: The aggregate shall be well graded when tested in accordance with ASTM C-136 and C-117. The percentage composition by weight shall be within Table 702-1.

TABLE 702-1			
CRUSHED AGGREGATE GRADATION			
Sieve Sizes (Square Openings)	Percentage by Weight Passing Sieve		
	Select Material		Aggregate Base
	Type A	Type B	
3"	100	100	100
1 1/2"			
1 1/4"			
No. 4	30-75	30-70	38-65
No. 8	20-60	20-60	25-60
No. 30	10-40	10-40	10-40
No. 200	0-12	0-12	3-12

702.2.3 Plasticity Index: Unless otherwise noted, the Plasticity Index as tested in accordance with AASHTO T-146 Method A (Wet Preparation), T-89 and T-90 shall not be more than 5.

702.3 PROCESSED NATURAL MATERIAL:

702.3.1 General: Processed natural material shall consist of hard, durable fragments of stone or gravel and a filler of sand or other finely divided mineral matter. It shall be free from an excess of soft or disintegrated pieces, alkali, adobe, vegetable matter, loam, or other deleterious substances.

702.3.2 Physical Requirements: When sampled and tested in accordance with standard test methods, the aggregate shall meet the following requirements:

(A) Percentage of Wear: When tested in accordance with ASTM C-131, the percentage of wear shall not exceed 40 percent after 500 revolutions.

(B) Plasticity Index: When tested in accordance with AASHTO T-146 Method A (Wet Preparation), T-89 and T-90, the plasticity index shall not be more than 5.

(C) Liquid Limit: When tested in accordance with AASHTO T-89, the liquid limit shall not be more than 25 percent.

702.3.3 Crushed Material: Crushed material is not required, but may be incorporated in the finished product.

702.3.4 Grading: The aggregate shall conform to the sieve analysis in this specification except that the least dimension of the maximum particle size shall not exceed 2/3 of the compacted thickness of the specified lift being placed.

702.4 DECOMPOSED GRANITE:

Decomposed granite shall be any granitoid igneous rock which has been weathered in place and which has as principal constituents granular fragments of quartz and feldspar. It may also contain fragments of granitic rock not yet broken down into the component minerals. This material shall remain stable when saturated with water. Particles larger than 3 inches, which will not be broken in the process of rolling and tamping during construction, shall not be used.

Decomposed granite shall conform to the following requirements:

(A) When tested in accordance with this specification, not more than 20 percent shall pass the No. 200 mesh sieve.

(B) The P.I. of material passing the No. 200 sieve prior to testing shall not be less than 3 nor greater than 10. The Plasticity Index shall be tested in accordance with AASHTO T-146 Method A (Wet Preparation), T-89 and T-90.

702.4.1 Preparation of Test Specimens: A quantity of sufficient size to have a dry weight of 15 pounds shall be selected and dried to constant weight at a temperature between 215°F. and 230°F. Fifteen pounds of this material shall then be subjected to 500 revolutions in a Los Angeles abrasion machine, as described in Section 701, except that nothing shall be placed in the drum other than the material to be tested.

The material that has been subjected to the breakdown shall be tested in accordance with ASTM C-117 to determine the percentage of material finer than a No. 200 mesh sieve by washing.

RIPRAP

703.1 STONE:

Stone for plain and grouted riprap shall be sound and durable, free from seams and coatings, and of such characteristics that it will not disintegrate when subjected to the action of water. Loss by abrasion shall not exceed the limits specified in Section 701.

Stone shall be of shapes which will form a stable protection structure of the required depth. Rounded boulders or cobbles shall not be used on slopes steeper than 2 to 1 unless grouted. Angular shapes may be used on any slope. Flat or needle shapes will not be acceptable unless the thickness of the piece is more than 1/3 the length.

Waste concrete may be used, if the pieces are sound free from coatings, and meet the size requirements specified for a stone.

703.2 SIZE OF STONE:

Riprap stone shall be as large as can be conveniently placed in a layer of the required depth. The stones, excepting small stones and spalls used to chink interstices shall weigh not less than 10 pounds and at least 50 percent of the stone shall weigh not less than 100 pounds.

703.3 CONCRETE:

The portland cement, aggregates and mixing shall be as specified in Section 725 and as herein specified. The aggregate may be pitrun material, at least 80 percent of which shall pass a 1 1/2 inch square mesh screen. Separating aggregates by primary sizes will not be required. Los Angeles rattler tests and soundness tests will not be required.

The mixed concrete shall contain 376 pounds of portland cement per cubic yard.

The amount of water shall be such as to produce a mixture with a slump of 3 to 5 inches, when tested in accordance with ASTM C-143.

703.4 SACKS:

Sacks shall be made of burlap not lighter than 10 ounce and shall be approximately 19 1/2 inches by 36 inches measured inside the seams when the sack is laid flat. Sound reclaimed sacks may be used. The capacity of each sack shall be 1.25 cubic feet. Each sack shall contain 1 cubic foot of concrete loosely placed so as to leave room for folding the open end, the fold just enough to retain the concrete at the time the filled sacks are placed. Immediately after filling, the sacks shall be placed and lightly trampled to cause them to conform with the ground surface and with adjacent sacks in place.

PORTLAND CEMENT TREATED BASE

705.1 GENERAL:

The cement treated base shall consist of furnishing all materials in accordance with these specifications. The estimated cement requirement is 3 1/2 percent by weight of the dry aggregate. The cement shall be Type II, low alkali.

Municipality	Supplements
PH:	5.1 General: Change the second sentence that reads "The estimated cement requirement is 3-1/2 percent by weight of the dry aggregate." to read: The estimated cement requirement is 5 percent by weight of the dry aggregate.

705.2 AGGREGATE FOR CEMENT TREATED BASE:

The aggregate for cement treated base shall conform to the requirements of Section 701 except the plasticity of the material passing the No. 40 sieve shall not exceed 5 and the grading shall be per Table 705-1.

TABLE 705-1	
CEMENT TREATED BASE GRADATION	
Sieve Size	Percentage By Weight Passing Screen
1 1/2 inches	100
No. 4	40-70
No. 40	30 Max.
No. 200	38000

705.3 PORTLAND CEMENT AND WATER:

Portland cement and water shall conform to the requirements of Section 725.

705.4 COMPRESSIVE STRENGTH OF CEMENT TREATED BASE:

The minimum compressive strength at 7 days shall not be less than 500 psi when tested in accordance with ASTM D-1633.

705.5 BITUMINOUS MATERIAL FOR CURING SEAL:

Bituminous material for curing seal shall conform to the requirements of Sections 712 or 713 for the type specified.

RECLAIMED ASPHALT PAVEMENT

Municipality	Supplements
ME:	AA. Section 709 and 719 Reclaimed Asphalt Pavement shall be used only where specified in the Plans and Special Provisions.

709.1 DESCRIPTION:

Reclaimed Asphalt Pavement (RAP) is pavement containing RAP asphalt and RAP aggregates, which has been processed to 1 1/2 inches maximum size and is free of detrimental quantities of organic, non-granular soils and deleterious materials. The stored RAP shall be uniform in appearance and well graded from fine to coarse.

709.2 STORAGE:

RAP shall be stored in such a manner to permit ready inspection and shall be protected from contamination. Any portion of the stockpile that has been consolidated so that the uniformity is affected, will require reprocessing prior to use.

709.3 TEST REQUIREMENTS:

Prior to the use of RAP in a recycled asphalt concrete mix, the reclaimed asphalt concrete supplier shall furnish the Engineer with the following test reports from the stockpiles that are to be used for recycling.

- (A) Sand equivalent test of the unextracted RAP: Minimum of 80 when tested in accordance with ASTM D-2419 or AASHTO T-176.
- (B) RAP asphalt content ASTM D-2172 and D-1856.
- (C) Gradation test of the sample aggregate, after removal of the RAC per Section 710.4.2, using sieve sizes per Section 710.4.1, for the appropriate mix.

ASPHALT CONCRETE

710.1 GENERAL:

Asphalt concrete shall be a mixture of asphalt cement and mineral aggregates. Mineral admixture, mineral filler and anti-stripping agent shall be included in the mixture when required by the mix design or by the Engineer. All materials shall be proportioned by weight, volume or a combination in a central mix plant in the proportions required by the mix design to provide a homogeneous and workable mass.

The asphalt concrete mixes shall be of the types shown in Table 710-1.

TABLE 710-1			
ASPHALT CONCRETE MIXES			
Designation (mm)	Application	Design Target Lift Thickness For Mixes Above The Restricted Zone, inches	Design Target Lift Thickness for Mixes Below The Restricted Zone, inches
9.5	Surface Course	1.0 inches	1.5 inches
12.5	Surface Course	1.5 inches	2.0 inches
19	Base or Surface Course	2.5 inches	*3.0 inches
25	Base Course	3.0 inches	4.0 inches

*19mm mixes designed below the restricted zone are not for use as a surface course.

The designation is the nominal maximum aggregate size of the mix. The nominal maximum aggregate size is defined as the next largest sieve size above the first standard sieve to retain more than 10 percent of the mineral aggregate. The standard sieve sizes are 9.5 mm, 12.5 mm, 19 mm and 25 mm.

Each mix shall be designed for low, or high traffic conditions. Low traffic conditions are conditions where the asphalt mix will be subject to low volume and low weight vehicle usage. Examples of this condition are residential streets, most parking lots and residential minor collector streets. High traffic conditions are conditions where the asphalt mix will be subject to high volume and/or heavy weight vehicle usage as found on major collector, arterial and commercial streets. Street classifications (i.e. minor collector and major collector shall be determined by the specifying agency.

Municipality	Supplements
ME:	BB. Subsection 710.1 – Add the following to this subsection: Unless otherwise noted, all hot asphalt pavement shall meet the latest edition of the “Hot Asphalt Mix Criteria” dated April 1, 1996 as established by the East Valley Asphalt Committee. Additionally, all hot asphalt mixes provided for this project shall be approved in writing by the East Valley Asphalt committee prior to its use. Copies of the “Hot Asphalt Mix Criteria” can be obtained at no cost from the Building Safety Desk at 55 North Center Street, Mesa, Arizona.

Municipality	Supplements
SC:	710.1 GENERAL: <i>Add the following paragraph:</i> Mixes shall be designated as “R” type (such as R-9.5, R-12.5, etc.) conforming to low traffic design criteria, or “A” type (such as A-12.5, A-19, etc.) conforming to medium and high traffic design criteria. <i>Delete Table 710-1 in its entirety and replace with the following:</i>

TABLE 710-1		
ASPHALT CONCRETE MIXES		
Designation (mm)	Application	Design Target Lift Thickness (in.)
9.5	Surface Course	1-1/2"
12.5	Surface Course	2"
19.0	Base or Surface Course	3"
25.0	Base Course	4"
37.5	Base Course	5"

710.2 MATERIAL:

Municipality	Supplements
PH:	710.2 Composition And Grading: The grading of the combined aggregates shall be such as to conform to the requirements indicated in the following tabulations in which the percentages shown are based on the weight of dry aggregate only.

Municipality	Supplements
PH:	710.3 Storing, Drying, and Screening Aggregates: 710.3.1 Stockpiling (Cold Feed Separation): Aggregate for Dense Graded Mixes shall be separated and stockpiled into two or more sizes of aggregate: If the mineral aggregate is separated into two sizes, one stockpile or bunker shall contain material of which a minimum of 80 percent will pass a No. 4 sieve and the other stockpile or bunker shall contain material of which a minimum of 80 percent will be retained on the No. 4 sieve. If the mineral aggregate is separated into more than two sizes, at least two of the stockpiles or bunkers shall comply with the above and the sizes and tolerances shall be as approved by the Engineer. The grading of the cold feed stockpiles, or bunkers, for the duration of any one project shall not deviate from the grading as determined at the beginning of the project by more than the following tolerances: <p style="text-align: center;">Stockpile Tolerances</p> Aggregate passing 3/4", 3/8", No. 4, No. 8, & No. 30 ± 10 Percent Aggregate passing No. 200 ± 4 Percent Any material added to the stockpiles, or bunkers, during the progress of the project shall comply with the above requirement; however, the resulting gradation shall be within the specification limits. In placing materials in storage or in moving them from storage to the drier, any method which may cause the segregation, degradation, contamination, or the combining of materials of different gradings which will result in any stockpile or bunker failing to meet the requirements shall be discontinued and the material shall be reprocessed or wasted.

710.2.1 Asphalt Cement: The asphalt cement specified in this section has been developed for use in desert climate conditions. Should it be utilized in other climates, consideration should be given to adjustments in the asphalt selection. The asphalt cement shall be a performance grade asphalt conforming to the requirements of Section 711 for PG 70-10, unless otherwise specified in the plans or special provisions.

Municipality	Supplements
PH:	<p>10.2.1 General</p> <p>Asphalt concrete shall consist of a mixture of paving asphalt and mineral aggregate which, with or without the addition of mineral filler and blending sand as may be required, shall be mixed at a central mixing plant in the proportions hereinafter specified to provide a homogeneous and workable mixture.</p> <p>Asphalt concrete is designated at Type A-1½ Base Course; Type C-3/4 Base, Surface or Single Course; and Type D-½ Single or Surface Course.</p> <p>The asphalt to be mixed with mineral aggregate shall be paving grade asphalt conforming to Section 711, and shall be PG 64-16 to PG 70-10 as directed by the Engineer, unless otherwise specified in the special provisions.</p>

710.2.2 Aggregate: Coarse and fine aggregates shall conform to the applicable requirements of Section 701, except as modified herein.

Coarse aggregate is material retained above the 2.36 mm sieve and fine aggregate is material passing the 2.36 mm sieve.

Blend sand (naturally occurring or crushed fines) shall be clean, hard and sound material which will readily accept asphalt coating. The blend sand grading shall be such that, when it is mixed with the other mineral aggregates, the combined product shall meet the grading requirements of the designated mix, as specified in tables 710-2, 710-3 and 710-4.

The natural sand shall not exceed 15 percent by weight of the total aggregate for all mixes.

Municipality	Supplements
PH:	<p>10.2.2 Aggregate:</p> <p>Coarse and fine aggregates shall conform to the applicable requirements of Section 701 except as modified herein.</p> <p>Coarse aggregate is material retained on the No. 4 sieve and fine aggregate is material passing the No. 4 sieve. Blending sand shall be clean, hard and sound material, either naturally occurring sand or crushed fines, which will readily accept asphalt coating. The exact grading requirements shall be such that, when it is mixed with the mineral aggregate, the combined product shall meet the requirements of the designated mix as specified elsewhere in this specification.</p>

Municipality	Supplements																
PH:	<p>710.2.4 Combined Aggregates: The combined aggregates sampled after all processing, except the adding or asphalt and mineral filler, shall conform to the following quality requirements.</p> <p>The ratio of the percentage of aggregate by weight passing the No. 30 sieve, to that passing No. 8 sieve, shall not exceed 65 percent of all dense graded asphalt concrete mixes.</p> <p>At least 75 percent by weight of the aggregate retained on the No. 8 sieve shall consist of particles which have at least one rough, angular surface produced by crushing.</p> <p>Subsection 710.2.5 Job-Mix Formula: The City of Phoenix Materials Lab will provide the Job Mix Formula (JMF) letter for “The Standard Mix”. If the Contractor chooses to use a mix other than the “Standard Mix”, He must establish a satisfactory job mix formula based upon tests performed on the material. The contractor or his supplier must submit samples of this mix, at least 3 weeks prior to use, to the City of Phoenix Materials lab for verification. The formula shall indicate the definite percentage for each sieve fraction of aggregate, and for bituminous cement; also the intended temperature of completed mixture at the time it is discharged from the mixer. The material furnished shall conform to the approved job-mix formula within the tolerances specified herein.</p> <p style="text-align: center;">Job-Mix Tolerances</p> <table border="0" style="width: 100%;"> <tr> <td>Aggregate passing sieve No. 4 and larger</td><td style="text-align: right;">± 7 percent</td></tr> <tr> <td>Aggregate passing sieves No. 8 and 30</td><td style="text-align: right;">± 5 percent</td></tr> <tr> <td>Aggregate passing sieve No. 200</td><td style="text-align: right;">± 2 percent</td></tr> <tr> <td>Temperature of mixing and placing</td><td style="text-align: right;">280° to 310° F</td></tr> </table> <p>The tolerances used in conjunction with the job-mix formula shall be such that the resulting gradation shall be within the specification limits. The amount of liquid asphalt, by weight, to be added to the different gradations of the mineral aggregate shall be as specified and determined by the Engineer. The amount specified by the Engineer shall be within the following range of the percentages of the total mixed material:</p> <table border="0" style="width: 100%;"> <tr> <td style="width: 70%;">Mix Description</td><td style="text-align: right;">Percentage of Asphalt Range</td></tr> <tr> <td>A – 1 ½ “</td><td style="text-align: right;">4.0 to 5.0</td></tr> <tr> <td>C – ¾</td><td style="text-align: right;">5.0 to 6.0</td></tr> <tr> <td>D – ½</td><td style="text-align: right;">5.0 to 6.0</td></tr> </table> <p>The allowable tolerance in percentage of asphalt content from that percentage specified by the Engineer, when sampled and tested in accordance with AASHTO T-164 and T – 168 as modified by Contracting Agency shall be plus or minus 0.4 percent.</p> <p>After the job-mix formula has been approved and the mixing plant selected, the Contractor and/or his supplier shall not change either of the above or utilize additional mixing plants without prior approval of the Engineer.</p>	Aggregate passing sieve No. 4 and larger	± 7 percent	Aggregate passing sieves No. 8 and 30	± 5 percent	Aggregate passing sieve No. 200	± 2 percent	Temperature of mixing and placing	280° to 310° F	Mix Description	Percentage of Asphalt Range	A – 1 ½ “	4.0 to 5.0	C – ¾	5.0 to 6.0	D – ½	5.0 to 6.0
Aggregate passing sieve No. 4 and larger	± 7 percent																
Aggregate passing sieves No. 8 and 30	± 5 percent																
Aggregate passing sieve No. 200	± 2 percent																
Temperature of mixing and placing	280° to 310° F																
Mix Description	Percentage of Asphalt Range																
A – 1 ½ “	4.0 to 5.0																
C – ¾	5.0 to 6.0																
D – ½	5.0 to 6.0																

710.2.2.1 Aggregate Structure: For mix design only, the combined aggregates, including the mineral admixture, mineral filler and anti-strip agent, shall meet the gradation requirement in Table 710-2.

TABLE 710-2					
GRADATION REQUIREMENTS-PERCENT BY WEIGHT PASSING					
Sieve Size (mm)	Designation (mm)				
	9.5	12.5	19	25	37.5
50	–	–	–	–	100
37.5	–	–	–	100	90-100
25	–	–	100	90-100	<90
19	–	100	90-100	<90	–
12.5	100	90-100	68-88	–	–
9.5	90-100	<90	56-80	–	–
4.75	<90	–	–	–	–
2.36	32-67	28-58	23-49	19-45	15-41
0.075	2.0-10.0	2.0-10.0	2.0-8.0	1.0-7.0	0-6.0

The limits of a restricted zone shall be defined as the sieve gradations in Table 710-3.

TABLE 710-3					
RESTRICTED ZONE BOUNDARY Percent Passing (Minimum-Maximum)					
Sieve Size (mm)	Designation (mm)				
	9.5	12.5	19	25	37.5
4.75	–	–	–	39.5-39.5	34.7-34.7
2.36	47.2-47.2	39.1-39.1	34.6-34.6	26.8-30.8	23.3-27.3
1.18	31.6-37.6	25.6-31.6	22.3-28.3	18.1-24.1	15.5-21.5
0.6	23.5-27.5	19.1-23.1	16.7-20.7	13.6-17.6	11.7-15.7
0.3	18.7-18.7	15.5-15.5	13.7-13.7	11.4-11.4	10.0-10.0

When plotted on a Federal Highway Administration 0.45 Power Gradation Chart, the aggregate grading shall miss the restricted zone as shown in Table 710-3. Any gradation that passes through the restricted zone will be considered unacceptable. When the asphalt pavement will be subject to high traffic conditions, the gradation curve shall fall below the restricted zone.

When the asphalt pavement will be subject to low traffic conditions, the gradation curve may fall on either side of the restricted zone.

710.2.2.2 Aggregate Characteristics: The coarse and fine aggregates shall comply with the requirements of Table 710-4.

710.2.3 Mineral Filler, Mineral Admixture and Anti-Stripping Agent: Mineral filler shall conform to the requirements of AASHTO M-17. The amount of mineral filler shall be determined by the mix design.

Mineral admixture or anti-stripping agent shall be dry hydrated lime, conforming to the requirements of ASTM C-207 Type N, or Portland cement conforming to Section 725. The amount of hydrated lime or Portland cement used shall be determined by the mix design.

When liquid anti-stripping agents are used, the agent shall conform to the requirements of AASHTO designation R 15-89. The agent shall be added in accordance with the manufacturer's recommended dosage rate.

Other mineral filler, mineral admixture, or anti-stripping agents, shall be approved by the Engineer prior to start of the mix design

Municipality	Supplements
PH:	<p>10.2.3 Mineral Filler and Anti-Stripping Agent:</p> <p>(A) Mineral filler shall conform to the requirements of AASHTO M-17. The mineral filler shall be dry hydrated lime conforming to the requirements of ASTM C-207 Type N, or portland cement conforming to Section 725 or other approved mineral filler shall be added to the aggregate in accordance with the requirements contained herein. The amount of mineral filler to be used shall be determined by the Engineer. The method of adding the mineral filler shall be such that the aggregate is uniformly coated and the mineral filler is uniformly distributed without loss or waste within the material prior to adding the asphalt to the mixture.</p> <p>(B) When aggregate is subject to stripping, as determined by one of the two procedures below, dry hydrated lime conforming to the requirements of ASTM C-207 Type N, portland cement conforming to Section 725 or other approved anti-strip agent shall be added. Hydrated lime and portland cement shall be added in accordance with Subsection 710.2.3. Other approved no strip agents shall be added in accordance with the manufacturer's recommendations and approved by the Engineer.</p> <p>(1) From a field sample, cut out 800-1000 grams of asphalt mix. Spread the mix out in loose thin layer, the thickness being no larger than the largest size aggregate. Allow the sample to air-season at room temperature for 24 hours \pm 2 hours. Then place the entire sample in non-breakable container with a water tight lid. The sample should not exceed half of the container's volume. (A 4-inch x 8-inch plastic concrete field test mold may be used. The lid can be taped to obtain a water tight seal). The sample shall be completely covered with distilled water at room temperature. The container shall be covered (sealed) and allowed to stand for a period of 24 hours \pm 2 hours. Then the container with sample shall be shaken vigorously for a period of 15 minutes. Shaking shall be accomplished by use of gyro sieve shaker or similar type device.</p> <p>After shaking, decant the sample over a No. 8 plus material and air dry for a visual examination. The amount of stripping shall be visually estimated in 10 percent increments and classified under the following: 0% to 20% stripping observed - excellent; 20% to 40% - above average; 40% to 60% - average; 60% to 80% - poor; 80% to 100% - very poor. NOTE: The average may vary slightly depending on the aggregate source. Approximately ten selected samples may be retained representing each 10% increment for use in establishing a comparison rating chart.</p> <p>(2) ASTM D-1075 with a minimum dry strength of 250 psi and a minimum wet strength equal to or greater than 60% of the dry strength test value.</p>

TABLE 710-4		
COARSE/FINE AGGREGATE REQUIREMENTS		
Characteristics	Low Volume Traffic	High Volume Traffic
Fractured Faces % (Coarse aggregate only AZ test method 212D)	75.0, 1 or more	85.0, 1 or more 80.0, 2 or more
Uncompacted Voids % Min. (AASHTO T 304, Method A)	42	45

Flat & Elongated Pieces % Max.	10	10
Sand Equivalent % Min. (AASHTO T 176)	40	50
Plasticity Index (AASHTO T 90)	Non-plastic	Non-plastic

710.3 MIX DESIGN REQUIREMENTS:

Municipality	Supplements
PH:	<p>10.3.1 General:</p> <p>Unless authorized by the Engineer, no work shall be started on the project until the Contractor or his supplier has submitted an asphalt mix design acceptable to the Engineer. The mix design shall be prepared by a laboratory that is accredited through the AASHTO Accreditation Program in Hot Mix Asphalt Aggregates and Hot Mix Asphalt or The National Bureau of Standards in the National Voluntary Laboratory Accreditation Program (NVLAP) for Construction Services (Asphalt). The laboratory shall be under the direct supervision of a Civil Engineer, registered by the State of Arizona, with a minimum of five years experience in the development of asphalt concrete mix designs. A copy of the certification shall be required with each mix design submittal. The date of the design shall not be older than one year from the date of submittal, unless supportive documentation is provided and approved by the Engineer.</p> <p>The mix design report shall include the following elements.</p> <ol style="list-style-type: none"> (1) A description of all products that are incorporated in the asphalt concrete along with a statement disclosing the sources of all products, including mineral admixtures, asphalt modifiers, anti stripping agents and their method of introduction. (2) The mix plant location, a copy of the certification of Hot Mix Asphalt Production Facilities by Arizona Rock Products Association and a copy of all certifications for weighing and metering devices within the plant. (3) The results of testing performed on all aggregates to assure compliance with Section 701 and 710. (4) The results of all laboratory tests associated with the mix design development, a plot of the gradation on the Federal Highway Administration's 0.45 Power Gradation Chart, plots of all compaction curves and the results of the moisture damage testing (Section 710.3.6). (5) A specific recommendation for design asphalt content and any limiting conditions that may be associated with the use of the design, such as minimum percentages of crushed or washed fine aggregate. (6) Mixing and compaction temperatures. (7) The supplier's product code, the laboratory Engineer's seal (signed and dated), and the date the design was performed. <p>The mix design shall be submitted to the Agency by the Contractor for which it was developed. This submittal shall include a certification, signed by the Officer of the Contractor or his supplier stating that the materials submitted for the mix design are representative of those that will be utilized for the production of the asphalt concrete represented by the mix design. Once the mix design has been approved by the agency and the mixing plant selected, the Contractor and/or his supplier shall not change plants nor utilize additional mixing plants without prior approval of the Engineer. Any changes in the plant operation, the producers pit, the asphalt cement, including modifiers, or any other item that will cause an adjustment in the mix, shall be justification for a new mix design to be submitted.</p>

710.3.2 Mix Design Criteria: The mix design shall be performed by one of two methods, Marshall Mix Design or Superpave™ Mix Design. The method shall be specified on the plans, special provisions, or by the Engineer. A minimum of 4 points will be used to establish the mix design results.

Municipality	Supplements
PH:	<p>10.3.2 Drying and Heating:</p> <p>The mixing plant shall be provided with accurate mechanical means for feeding the aggregates from the stockpiles or bunkers into the drier at such a rate that a uniform production and temperature of dried aggregates will be obtained.</p> <p>The feeders may be of the apron belt, reciprocating plate, vibrating type or tip gate, and shall have accurate and separate adjustments. These adjustments shall be capable of being locked in any position and the feeders shall be capable of delivering the required aggregate in the proper proportions.</p> <p>Drying shall continue until the moisture content is not greater than 0.75 percent. In special cases when the aggregate is unusually porous, a moisture content in excess of 0.75 percent may be permitted at the discretion of the Engineer. In no event shall the aggregate be heated beyond the lowest temperature necessary for proper drying, mixing, spreading, and compacting.</p> <p>The drier shall be provided with a heat-indicating device in order that the temperature of the aggregate leaving the drier may be determined. The heat-indicating device shall be accurate to the nearest 10°F., and shall be installed in such a manner that a fluctuation of 10°F in the aggregate temperature will be shown by the heat-indicating device within one minute.</p> <p>The drier shall be equipped with an approved type of dust collector system capable of removing objectionable or excess dust from the aggregate and either wasting the material so collected or returning all or any portion of it uniformly to the mixer, as the Engineer may direct. Dust collector shall comply with the Maricopa County Bureau of Air Pollution Control Rules and Regulations as adopted by the County Board of Supervisors and applicable State laws or local ordinances.</p>

710.3.2.1 Marshall Mix Design: The Marshall Mix Design shall be performed in accordance with the requirements of The Asphalt Institute's Manual, MS-2 "Mix Design Methods for Asphalt Concrete." The mix shall utilize the compactive effort described in AASHTO T-245, "Standard Method of Test for the Resistance to Plastic Flow of Bituminous Mixtures Using Marshall Apparatus." The mix shall comply with the criteria in Table 710-5.

TABLE 710-5		
MARSHALL MIX DESIGN CRITERIA		
Characteristics	Low Traffic	High Traffic
Compactive Effort (Each Side of Specimen)	50 blows	75 blows
Marshall Stability, N	3,500 Minimum	8,000 Minimum
Marshall Flow, 0.25 mm	38214	38214
Effective Air Voids, %	4.0±0.2	4.0±0.2
Voids in Mineral Aggregate, %	Table 710-8	Table 710-8
Voids Filled with Asphalt, %	70-80	65-75
Calculated Film Thickness	10-14 Microns	8-14 Microns

The calculated film thickness in Table 710-5 and 710-6 should be determined using the following formula:

$$T_f = \frac{(4876.8) (P_{be})}{(SA) (P_s) (G_b)}$$

Where,

T_f = Asphalt Film thickness, Microns

P_{be} = Effective Asphalt Content, percent by total weight of mixture

SA = Surface Area of Aggregate (square feet per pound)

P_s = Aggregate Content, Percent by Total weight of Mixture

G_b = Specific Gravity of Asphalt Cement

Surface Area (SA) calculations should follow procedures outlined in Chapter 6 of the Asphalt Institute Manual Series No. 2 (MS-2), Sixth Edition.

710.3.2.2 Superpave™ Mix Design: The Superpave™ Mix Design shall be performed in accordance with the requirements of The Asphalt Institute's "Superpave™ Volumetric Mix Design Manual, SP-2." The design shall utilize the Superpave™, gyratory compactor described in AASHTO TP-4, "Preparation of Compacted Specimens of Modified and Unmodified Hot Mix Asphalt by Means of the SHRP Gyratory Compactor" and AASHTO PP-2, "Short and Long-term Aging Bituminous Mixes." The mix shall comply with the criteria in Table 710-6.

TABLE 710-6			
SUPERPAVE™ MIX DESIGN CRITERIA			
	Low Traffic	High Traffic	Criteria
Gyrations Nini Ndes Nmax	775115	8100160	<89* 96±0.2* <98*
%Voids	4.0±0.2	4.0±0.2	—
%Voids in Mineral Aggregate	Table 710-8	Table 710-8	—
%Voids Filled	70-80	65-75	—
Calculated Film Thickness	10-14 Microns	8-14 Microns	

* These criteria are expressed as a percentage of the maximum theoretical specific gravity.

710.3.3 Asphalt Cement Content: The design asphalt cement content shall be expressed as a percentage of the total mix weight and shall be stated in the mix design to the nearest 0.1 percent. Table 710-7 is the allowable range of design asphalt cement contents for each mix designation. If the mix design places the design asphalt content outside of these ranges, the Contractor or his supplier will review the test data with the Engineer to determine if the design is acceptable. The Engineer shall approve the variance prior to the completion of the mix design.

TABLE 710-7		
ASPHALT CONTENT (%)		
Mix/ Designation (mm)	For Gradations Above the Restricted Zone	For Gradations Below the Restricted Zone
9.5 and 12.5	5.5 to 6.5	5.0 to 6.0
19	5.0 to 6.0	4.5 to 5.5
25.0 and 37.5	4.0 to 5.0	3.5 to 5.0

710.3.4 Voids in Mineral Aggregate: The voids in the mineral aggregate shall comply with the criteria in Table 710-8, with respect to the nominal maximum aggregate size.

TABLE 710-8		
VOIDS IN MINERAL AGGREGATE		
Nominal Maximum Size/ Designation (mm)	Maximum Size (mm)	Minimum VMA (percent)
9.5	12.5	15
12.5	19	14
19	25	13
25	37.5	12
37.5	50	11

710.3.5 Dust Proportion: The dust proportion is defined as the ratio of the percent finer than the 0.075 mm sieve, including mineral filler, mineral admixture, and anti-stripping agent, to the effective binder content (P0.075/Pbe). The dust proportion shall be between 0.60 and 1.2 for aggregate gradations that fall below the restricted zone and between 0.80 and 1.4 for aggregate gradations that are above the restricted zone.

710.3.6 Moisture Sensitivity: The resistance to moisture damage shall be evaluated in accordance with AASHTO T-283, “Standard Method of Test for Resistance of Compacted Bituminous Mixture to Moisture Induced Damage,” without the optional freeze-thaw cycle. The asphalt concrete, at the design binder content, shall have a minimum average dry tensile strength of 500 kPa and a minimum tensile strength ratio of 0.70 when the aggregate gradation is below the restricted zone and a minimum average dry tensile of 750 kPa and a minimum tensile strength ratio of 0.60 when the aggregate gradation is above the restricted zone.

710.4 PRODUCTION TOLERANCES AND ACCEPTANCE:

Asphalt concrete from the mixing facility shall be accepted on the basis of acceptance tests of aggregate gradation, asphalt cement content, coarse/fine aggregates and volumetrics. Samples for acceptance tests will be taken by the Engineer or his representative at a minimum frequency of one sample for every 1,000 tons. The samples will be taken by the Engineer from behind the lay-down machine with a steel plate in accordance with Arizona Department of Transportation test method ARIZ 104b. The laboratory performing acceptance testing shall be accredited by the AASHTO Material Reference Laboratory (AMRL) in each of the tests used for acceptance. The acceptance samples shall be tested for unit weight and voids in accordance with ASTM D2041 and AASHTO T 166 or T 275 as applicable. The acceptance samples shall be tested for asphalt cement content, gradation, and uncompacted voids in accordance with ASTM D6307, C117, C136 and AASHTO TP304 Method A. Changes to the sampling and testing methods shall not be made without authorization from the Engineer.

Asphalt concrete not meeting the acceptance standards will be subject to removal, penalties, or other corrective action as described in sections 710.4.1, 710.4.2, 710.4.3 and 710.4.4 below. At the Engineer’s discretion, requests may be considered to allow material whose test results indicate “removal” or “rejection” to remain in place. If such a request is made and the Engineer agrees to consider it, the contractor shall retain an independent asphalt technologist that is a registered Engineer in the State of Arizona, to perform an Engineering Analysis. The qualifications of the asphalt technologist are subject to the approval of the Engineer.

The Engineering Analysis shall discuss requirements and life expectancy of the pavement. Recommendations for corrective action necessary to bring the pavement to an acceptable condition must be provided in the Engineering Analysis. For the purposes of this analysis, “acceptable condition” will be defined by:

- Pavement condition rating typical of new pavements
- Structurally adequate for the pavement’s design life (as defined by the specifying agency’s pavement design methods). For the purposes of this specification, the pavement design life is the “analysis period” and is typically 20 years.
- Expected time frame before the first routine maintenance activity will be 7 years or more. Revised 2004

If the construction contract is directly with a party other than a public agency, as in the case of permits, and the test results are in the ranges that would normally indicate any penalty, removal or rejection, the contractor shall retain an independent asphalt technologist to recommend corrective action as described above.

If the contractor has reason to question the validity of any of the acceptance test results, he may request that the Engineer consider verification tests for final acceptance. Any request for verification testing must describe the Contractor's reasons for questioning the validity of the original acceptance results and must clearly describe which set of acceptance tests are in question. The Engineer may either accept or reject the request for verification testing.

If the Engineer accepts the request for verification testing, he will engage an independent laboratory who is accredited by AMRL or equivalent in all of the acceptance tests. The independent laboratory shall be paid by the Engineer and shall perform a completely new set of acceptance tests (as required by 710.4 representing the area or set of tests in question).

These tests shall include asphalt cement content, aggregate gradation, Marshall or Gyratory unit weight, and maximum theoretical unit weight. Samples for verification testing shall come from sample splits from the acceptance tests held by the acceptance laboratory, or from additional samples cored from the roadway. The Engineer will determine which samples will be used for verification testing.

The number of samples taken will be in accordance with the Engineer's acceptance test frequency. The independent laboratory shall compile the test results and transmit them to both the Engineer and the Contractor. The independent laboratory shall include a letter signed by an Engineer registered in the State of Arizona, who is a specialist in asphalt concrete. The signed letter shall give an opinion that the material evaluated either does or does not comply with project specifications, and shall clearly describe any deficiencies.

If the difference in test results of the independent laboratory versus the original acceptance laboratory falls outside the multi-laboratory precision statements, for the test methods being used, the contracting Agency will bear the cost of the verification testing. If the difference in test results fall within the multi-laboratory precision statement, the cost for verification testing will be deducted from payments that were to be made to the Contractor. For test methods that do not have multi-laboratory precision statements, the cost for verification testing will be deducted from payments that were to be made to the contractor.

The Contractor shall remove any of the new pavement exhibiting bleeding, shoving or rutting and replace the asphalt concrete with new material meeting the specification requirements for the mix type involved. The width of the removal shall be wider than the roller width required for the replacement. The replacement shall be done any time within the one year warranty period for the project, and shall be done as many times as is necessary to correct the deficiency. Such replacement work shall be done at no additional cost to the contracting agency. The pavement will be considered to have rutted or shoved if measurements with an 8-foot straightedge indicate a depression in the pavement of 1/4 inch or more.

Municipality	Supplements
PH:	<p>10.4 Bin Separation Batch Plant</p> <p>After being dried and in advance of mixing with asphalt, the mineral aggregate shall be separated into three or more sizes and stored in separate bins.</p> <p>All mineral aggregate for mixes A – 1½ and C – ¾, Dense Graded, shall be separated into three or more bins as follows:</p> <p>(A) Bin No. 1</p> <p>Not less than 80 percent of the material in Bin No. 1 shall pass a No. 8 sieve.</p> <p>(B) Bin No. 2</p> <p>The sum of the percent of the material retained on a 3/8 inch sieve and the percent of the material passing a No. 8 sieve shall not exceed 25 percent.</p> <p>(C) Bin No. 3</p> <p>Not more than 20 percent of the material in Bin No. 3 shall pass a 3/8 inch sieve.</p>

	<p>Mineral aggregate for mix D – ½ Dense Graded, shall be separated into two or more separate bins as follows:</p> <p>(A) Not less than 80 percent of the material in Bin No. 1 shall pass a No. 8 sieve.</p> <p>(B) Not more than 20 percent of the material in Bin No. 2 shall pass a No. 8 sieve.</p> <p>Failure to comply with the requirements shall be corrected by drawing the bin and re-screening the material. If there is evidence of fine material hanging on the sides of the fine bin, the fine bin shall be equipped with a vibrating unit, which will effectively vibrate the side-walls of the bin and prevent any hang-up of segregated sizes while the plant is operating. A positive signal system shall be provided to indicate the low level of material in each bin. Each bin shall be provided with an overflow chute to prevent spilling into adjacent bins and to waste excess material from the bin. The inter-mingling of material between bins by the removal of patch-plates, or by other openings between bins, will not be permitted. The composite analysis of the bins as proportioned, shall comply with the grading limits required for the size mineral aggregate designated.</p>
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710.4.1 Aggregate Gradation: The Engineer at his discretion may accept the aggregate gradation on the basis of cold feed, hot bins, or by testing the aggregate after extraction by solvent or incineration methods. The testing shall be in accordance with AASHTO Designation T-11, “Standard Method of Test for Materials Finer Than 0.075 mm Sieve in Mineral Aggregates by Washing” and AASHTO Designation T-27, “Sieve Analysis of Fine and Coarse Aggregates” or in accordance with AASHTO T-30, “Standard Method of Test for Mechanical Analysis of Extracted Aggregate,” when solvent extraction or incineration methods are utilized to determine asphalt content.

The target values for all sieve sizes will be established by the mix design. The production tolerance for the gradation shall be tested against the following sieves: 0.075, 0.15, 0.6, 2.36, 4.75, 9.5, 12.5, 19, 25, 37.5 mm sieves. The aggregate gradation will be considered acceptable when the variations from the mix design percentages do not exceed the tolerances in Table 710-9 for a single event test. The full tolerance will be applied to the mix design percentages for acceptance. The restricted zone is considered a design requirement only.

TABLE 710-9	
ALLOWABLE AGGREGATE VARIATION	
Maximum Aggregate Size	100% passing
Nominal Maximum Aggregate Size	±7%
2.36 mm. Sieve to the Nominal Maximum Aggregate Size	±6%
0.150 mm and 0.600 mm. Sieves	±4%
0.075 mm. Sieve	±2%

710.4.2 Asphalt Cement Content: The asphalt content may be determined in accordance with AASHTO Designation T-164, “Quantitative Extraction from Bituminous Paving Mixtures,” AASHTO Designation T-287, “Asphalt Cement Content of Asphalt Concrete Mixtures by the Nuclear Method” or ASTM D6307 “Asphalt Content of Hot-Mix Asphalt by Ignition Method.” The asphalt content determined by solvent extraction methods may be corrected for a retention value determined in accordance with ARIZ 407d, “Determination of Asphalt Retained in Bituminous Mixtures.”

The Asphalt cement content shall be considered acceptable if it is within ±0.40% of the mix design target value. The Engineer will investigate variations beyond these limits with two additional core samples taken for each deficient acceptance test. Asphalt cement contents will be measured on the two core samples, and the average of all three tests shall be used to determine the asphalt cement content at that location.

When the asphalt cement content is outside of the $\pm 0.40\%$ tolerance by an amount from 0.0 to 0.2 percent points (by weight of the total mix), payment to the Contractor for asphalt concrete pavement will be reduced per Table 710.10. If the deviation is more than 0.2 percentage points, the materials represented by that test location will be removed and replaced at no additional cost to the contracting agency.

TABLE 710-10		
ASPHALT CEMENT CONTENT CORRECTIVE ACTION FOR DEVIATIONS		
Deviation from that permitted	When the contracting agency is the owner: Payment Reduction (\$ per ton of asphalt concrete)	When the contracting agency is not the owner (i.e. permits): Corrective Action
0.0 to 0.1% points	\$0.50/ton	No corrective action
Over 0.1 to 0.2% points	\$2.00/ton	Remove & Replace*
Over 0.2% points	Remove & Replace*	Remove & Replace*

* The limits of the corrective action shall be over the affected area, but not less than the paver width (or 12 feet, whichever is more) and for a distance of 660 feet or the entire length of the affected roadway, whichever is less.

The following exception to Table 710-10 may be applied at the discretion of the Engineer. When the asphalt cement content is higher than that established in Subsection 710.4.2 but not beyond 0.2 percentage points, the payment reduction may be waived if the in-place air voids and the laboratory air voids (determined by gyratory or Marshall as applicable) fall within the following ranges. For “heavy” traffic mixtures, the laboratory void range shall be 2.8-6.2% and the in-place void range shall be 4.0-8.0%. For “low” traffic mixtures, the laboratory void range shall be 2.8-6.2% and the in-place void range shall be 3.0-7.0%.

710.4.3 Coarse/Fine Aggregates: The coarse/fine aggregate requirements shall be considered acceptable if the test values on production material falls within the mix design requirements established in Table 710-4, except for the uncompacted voids.

The uncompacted voids may be determined from collected samples in accordance with AASHTO TP-304, Method A, “(Test Method for Uncompacted Void Content of Fine Aggregate as influenced by Particle Shape, Surface Texture & Grading, Method A).” This result shall be calculated using the fine aggregate bulk oven dry specific gravity reported in the mixture design report. This same procedure may be performed on aggregate resulting from solvent extraction or incineration methods. The fine aggregate angularity shall be considered acceptable if the test value on production material is not less than the uncompacted voids specified on the mix design minus 1.5%.

710.4.4 Volumetrics: Procedures in the Asphalt Institute’s manual, MS-2 “Mix Design Methods for Asphalt Concrete” or the Asphalt Institute’s “Superpave™ Volumetric Mix Design Manual, SP-2” shall be used to determine the volumetrics. The volumetric values shall be considered acceptable if the test values on production material falls within the mix design criteria established in section 710.3.2 except for air voids.

The acceptance decision for air voids shall be based on Table 710-11.

TABLE 710-11		
LABORATORY VOIDS ACCEPTANCE AND PENALTIES		
Laboratory air Voids (Measured at N_{des} 50 or 75 blows as applicable)	When the contracting agency is the owner: Reduction in Payment (\$ per ton of Asphalt Concrete)	When the contracting agency is not the owner (i.e. permits): Corrective Action
Less than 1.5%	Removal	Removal
1.5-2.0%	\$1.25	Removal
2.1-2.7%	\$0.50	No corrective action
2.8-6.2%	Full Payment	No corrective action
6.3-6.9%	\$0.50	No corrective action
7.0-8.0%	\$1.25	Removal
Greater than 8.0%	Removal	Removal

For the purposes of assessing the penalties in Table 710-10, each day's production will be considered one lot. The penalties will be applied to the payment for asphalt concrete pavement for the entire lot and will be based on the average values of the acceptance tests made for that lot.

710.5 PRODUCTION REQUIREMENTS:

710.5.1 Quality Control: Quality control shall be the responsibility of the Contractor or his supplier. The Engineer reserves the right to obtain samples of any portion of any material at any point of the operations for his own use. Also, the Engineer reserves the right to order the use of any drying, proportioning and mixing equipment or the handling of any material discontinued which, in his/her opinion, fails to produce a satisfactory mixture.

The asphalt concrete mix produced shall conform to the properties of the mix design. When the asphalt concrete mix does not conform to the approved mix design properties, the production shall cease immediately.

In addition to other quality control responsibilities, the Contractor/Supplier/Producer shall provide testing at the frequencies listed in Table 710-12 during production of asphalt concrete. A laboratory, accredited in each of the listed tests by the AASHTO Materials Reference Laboratory (AMRL), shall perform the testing. The laboratory facilities where the tests are performed shall be located at the plant producing the asphalt concrete for the project.

TABLE 710-12		
CONTRACTOR QUALITY CONTROL TESTING REQUIREMENT		
Test	Sample Point	Frequency
Ignition Binder Calibration ASTM D6307-98	Stockpiles & storage tanks	1 per mix design per project
Ignition Binder Content & Gradation (ASTM D6307, C117 & C116)	Plant, truck, on-grade, etc.	1 per 1000 tons
Gyratory or Marshall Density, (ASTM D4013 or AASHTO T166)	Plant, truck, on-grade, etc.	1 per 1000 tons
Maximum Theoretical Density (ASTM D2041)	Plant, truck, on-grade, etc.	1 per day
Temperature	Storage silo or hot elevator	Continuous Reading
Aggregate Gradation (ASTM C117 & C136)	Cold Feed	1 per 750 Tons

Results of each test shall be provided to the Engineer's representative immediately as they are completed, and in no case later than the end of the day the asphalt was produced. The contractor shall utilize the results of this testing to control the asphalt concrete production. Production of asphalt concrete on consecutive paving days shall not commence until the prior day's test results have been submitted to the Engineer, and the appropriate action has been taken regarding the criteria listed in Table 710-12 and Table 710.13.

The guidelines in Table 710-13 and Table 710.14 shall be used to determine if the plant will require adjustment or stoppage. If the contractor's test results indicate the mixture does not comply with Criteria A, an adjustment to the plant will be required which will bring the production closer to the middle of the specification bands. The Contractor is responsible for determining the extent and the method of adjustment, and shall notify the Engineer's representative in writing of what adjustments were made.

If the Contractor's test results indicate the mixture is beyond the range established by Criteria S in Table 710-13, production shall cease immediately, and shall not resume (except as required to produce material for additional samples) until additional test results verify the adjustments will produce test results meeting Criteria A. The Engineer reserves the right to enforce the adjustment or stoppage criteria to the acceptance test results if the acceptance tests and the quality control tests are not in agreement.

TABLE 710-13		
CRITERIA FOR REQUIRED PLANT ADJUSTMENT		
Property	Criteria A-(Adjustment)	Criteria S-(Stoppage)
Binder Content	±0.3% of Mix Design	±0.4% of Mix Design
Gyratory Voids	4±1.5%	4±2.0%
Gradation	Table 710-14 below	Table 710-9 (MAG Specs)
Temperature	±10° C of Mix Design	±15° C of Mix Design

TABLE 710-14	
ALLOWABLE GRADATION VARIATION FROM MIX DESIGN TARGET	
Maximum Aggregate Size	100%
Nominal maximum Aggregate Size (NMAS)	±5%
2.36 mm. Sieve to NMAS	±4%
1.50 mm. And 0.66 mm. Sieves	±3%
0.75 mm. Sieve	±1.5%

The Contractor may make self-directed target changes to the approved mix design within the limits in Table 710-15. Requests for self directed target changes shall be made in writing and acknowledged by the Engineer prior to start of production for a lot. The self-directed target changes must meet contract requirements for mix design criteria and grading limits.

TABLE 710-15	
SELF DIRECTED TARGET CHANGES	
Measured Characteristics Gradation (sieve size) (mm)	Allowable Target Changes
9.50	±2%
2.36	±2%
0.425	±1%
0.075	None
Asphalt Cement Content	±0.2%
Effective Voids	None

The Contractor may propose target changes to the approved mix design for the engineer's approval. The Engineer will consider if the proposed target change will result in mix production that meets the contract requirements for mix design criteria and grading limits. For acceptance purposes, target changes will not be retroactive.

710.5.2 Handling and Storage of Aggregate: Aggregate shall be stockpiled so that segregation and contamination are minimized. Dividers of sufficient size to prevent intermingling of stockpiles shall be provided. This may be accomplished by sufficient separation of the stockpiles.

Any method of handling or moving the material which may cause the segregation, degradation, contamination or the combining of materials of different grades or stockpiles shall not be permitted. The affected material will be reprocessed or discarded.

710.5.3 Proportioning: The Contractor or his supplier shall provide documentation by calibration charts or other approved means showing the mineral aggregate, asphalt cement, mineral admixture, mineral filler or anti-stripping agent are being proportioned in accordance with the approved mix design. One set of documentation shall be provided for each 750 tons produced, however not less than one per each time the plant is placed in production. All measuring devices shall be calibrated at least annually by a technician licensed by the Arizona Bureau of Weights & Measures. Copies of the calibration documentation shall be an integral part of the mix design approval process which, if not acceptable, could be cause for rejection of the entire submittal.

If a mineral admixture or anti-stripping agent is added in a drum mix plant, a positive signal system and a limit switch device shall be installed in the plant at the point of introduction of the admixture. The positive signal system shall be placed between the metering device and the mixing drum, and utilized during production, whereby the mixing shall be stopped automatically if the admixture is not being introduced into the mixture.

No fine material which has been collected in the dust collection system shall be returned to the mixture unless the Contractor or his supplier propose in writing to utilize a specific portion of the fines and approved by the Engineer. If used, the fine material shall be metered at a uniform rate into the mixture.

When mineral filler is added to the asphalt mix, it shall be added prior to the asphalt cement. Also, the method of adding the mineral filler shall produce a uniform distribution without loss or waste of the material within the mixture. The amount of mineral filler shall be determined by the mix design.

Filler material, if required, shall be added separately and in a thoroughly dry condition. Heating of filler material will not be required.

When hydrated lime or Portland cement is added as a mineral admixture or anti-stripping agent, the method of adding the lime or cement shall be such that the aggregate will be uniformly coated. The amount of lime or cement used shall be determined by the mix design.

When mineral aggregate, asphalt cement, mineral filler, mineral admixture or anti-stripping agent are proportioned by weight, the scales used in batching the materials, all boxes, hoppers, buckets or similar receptacles used for weighing materials, shall be insulated against the vibration or movement from the rest of the plant. Errors in weighing, while the entire operation is running, shall not exceed two percent for any setting nor one and one-half percent for any batch. The asphalt shall be weighed in a heated, insulated bucket suspended from a springless dial scale or load cell system.

When mineral aggregate, asphalt cement, mineral filler, mineral admixture and/or anti-stripping agent are proportioned by volume, the correct portion of each mineral aggregate size introduced into the mixture shall be drawn from the storage bins by an appropriate type of continuous feeder. The feeder shall supply the correct amount of mineral aggregate in proportion to asphalt cement. Furthermore, the feeder shall allow each mineral aggregate size to be adjusted separately. The continuous feeder for the mineral aggregate shall be mechanically or electrically actuated.

If fine material sticks to the sides of the bin, the bin shall be equipped with vibrating unit which will effectively vibrate the side walls of the bin and prevent any hang up of segregated sizes while the plant is operating.

All scales or temperature devices shall be so located that the mixer operator and the plant inspector have an unobstructed close-up-view of the indicating or registering devices. The scales shall indicate the true net weight without the application of any factor. The dial for dial type scales shall not be less than 12 inches in diameter and the figures thereon shall be clearly legible.

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PH:	<p>10.5.3 Proportioning: Subsection 705.1 GENERAL: Change the second sentence that reads "The estimated cement requirement is 3-1/2 percent by weight of the dry aggregate." to read: The estimated cement requirement is 5 percent by weight of the dry aggregate. One set of documentation shall be provided for each 500 tons produced, however not less than one per each time the plant is placed in production.</p>

710.5.4 Drying and Heating: The mixing plant shall be provided with accurate mechanical means for feeding the aggregates from the stockpiles or bunkers into the drier at such a rate that a uniform production and temperature of dried aggregates will be obtained. Drying and heating shall be accomplished in such a manner as to preclude the mineral aggregate from becoming coated with fuel oil or carbon.

A recording pyrometer or other approved recording thermometric instrument, sensitive to a rate of temperature change not less than 6° C. per minute, shall be placed at the discharge chute of the drier to automatically record the temperature of the asphalt concrete or mineral aggregate. When requested, a copy of the recording shall be given to the Engineer at the end of each shift. The mixing temperature of the asphalt mix shall not exceed $\pm 10^{\circ}\text{C}$. of the mixing temperature stated on the approved mix design.

Heating of filler material will not be required.

Drying shall be to the extent that the moisture content of the asphalt concrete mix, when placed on grade immediately behind the paver, shall not exceed one half of one percent (0.5 %). The moisture content shall be determined in accordance with Arizona Test Method 406.

The drier shall be equipped with a dust collector system capable of removing objectionable or excess dust from the aggregate. The dust collector shall comply with the Maricopa County Bureau of Air Pollution Control Rules and Regulations as adopted by the County Board of Supervisors and applicable State laws or local ordinances.

710.5.5 Mixing: The production of the plant shall be governed by the rate required to obtain a thorough and uniform mixture of the materials not to exceed the rated capacity of the plant. Mixing shall continue until the uniformity of coating, when tested in accordance with the requirements of AASHTO T-195, is at least 95 percent.

The mineral aggregate, asphalt cement, mineral filler, mineral admixture and/or anti-stripping agent shall be mixed at a central mixing plant of the batch type mixer, continuous type mixer, or drum type mixer, as the Contractor or his supplier may elect. The plant shall be maintained and operated in accordance with the manufacturer's recommendations.

Pug mill mixers shall be of a twin-shaft type and shall be operated at the speed recommended by the manufacturer. It shall be equipped with paddles of sufficient size and number to deliver a thorough and uniform mixture. Should the paddles or other parts of the pug mill become worn to such extent as to adversely affect the quality of the mixing or allow leakage from the discharge gate, such parts shall be promptly replaced.

The amount of asphalt cement to be added to the mineral aggregate shall be as specified in the mix design. The asphalt cement shall be added at the temperature specified in the mix design or in Section 711.

The asphalt pump shall be a positive displacement type pump. The use of a pressure relief valve will not be permitted. The plant shall be equipped with an indicating meter between the pump and spray, and the meter shall be in good working condition and accurately record the volume of material pumped. All pipes, bins, fittings and meters shall be steam jacketed or otherwise properly insulated. The asphalt storage system shall be equipped with a device for automatic plant cut-off when the intake of the positive displacement pump is not working under positive pressure. Sampling ports shall be installed at the discharge end of the metering device for use by the Engineer in obtaining samples of the material.

A positive signal system shall be provided to indicate the low level of mineral aggregate in the bins of the batch plant and as the level of material in any one bin approaches the strike off capacity of the feed gate, the device will automatically and promptly close down the feed of all materials to the mixer. The plant will not be permitted to operate unless this signal system is in good working condition. Each bin shall have an overflow chute or divider to prevent material from spilling into adjacent bins or waste excess material.

The temperature of the asphalt concrete upon discharge from the mixer shall not exceed the maximum mixing temperature specified in the mix design. If the asphalt concrete is discharged from the mixer to a hopper, the hopper shall be constructed so that segregation of the asphalt concrete will be minimized.

710.5.6 Temporary Storage of Bituminous Mixtures: Use of surge bins or storage bins for temporary storage of hot bituminous mixtures will be permitted. The bituminous mixture may be stored in insulated and heated storage bins for a period of time not to exceed 12 hours. If the Engineer determines that there is an excessive amount of heat loss, segregation and/or oxidation of the mixture due to temporary storage, use of surge bins or storage bins will be discontinued.

710.5.7 Plant Inspection: Each hot mix asphalt facility, producing under this specification, shall be inspected biannually by a Civil Engineer registered in the State of Arizona and knowledgeable in batch plant operation. The Civil Engineer shall be independent and not an employee of the Contractor or the supplier. This inspection shall be performed in accordance with the "Certification of Hot Mix Asphalt Production Facilities" by the Arizona Rock Products Association. A copy of the current certification shall be an integral part of the mix design which, if found unacceptable, could be cause for rejection of the entire submittal.

710.6 TRANSPORT AND DELIVERY REQUIREMENTS:

The beds of the trucks, utilized to transport asphalt concrete, shall be coated with a release agent. The release agent shall be certified to be non-reactive with the bituminous material. If, in the opinion of the Engineer or plant operator, there is an excess of release agent applied to the truck bed, the driver will be required to raise the bed and drain off the excess agent. Diesel fuel will not be acceptable as a releasing agent.

Mixtures shall be delivered to the job site without segregation of the ingredients and within the lay down temperature range specified in the mix design.

At the time of delivery to the job site, the Engineer shall be provided with an legible delivery ticket that has the weight of the material from a measuring device, which has been certified by the Arizona Department of Weights and Measures. The delivery ticket shall contain the following information:

- (1) Date; (2) Supplier's name; (3) Plant location and/or plant number; (4) Ticket Number; (5) Truck Number; (6) Contractor's name; (7) Project name and/or location; (8) Production code/description with percent asphalt; (9) Mineral filler/additive and/or anti-stripping agent and percent; (10) Temperature at batching; (11) Time of batching, arrival and unloading; (12) Material weight or vehicle weight with and without material; and (13) Weight of accumulative loads.

Municipality	Supplements
PH:	<p>10.6 General Mixing</p> <p>All hot asphalt mixing facilities must be certified using the certification standards established by the Arizona Rock Products Association. Re-certifications must be performed on an annual basis. Copies of the certification or re-certifications shall be provided to the Engineer.</p> <p>The mineral aggregate and asphalt shall be mixed at a central mixing plant of the batch type mixes, continuous type mixes, or drum type mixer, as the Contractor may elect.</p>

	<p>The right is reserved to order the use of any drying, proportioning, and mixing equipment discontinued which, in the opinion of the Engineer, fails to produce a satisfactory mixture.</p> <p>Filler material, if required, shall be added separately and in a thoroughly dry condition. Heating of filler material will not be required.</p> <p>The amount of filler material to be used will be specified by the Engineer and shall be accurately proportioned by weight or by volumetric methods.</p> <p>The amount of asphalt to be added to the mineral aggregate shall be as specified in this specification.</p> <p>The temperature of the mineral aggregate shall not be higher than necessary for spreading and finishing at the time of adding the paving asphalt, and in no case shall the temperature for the Dense Graded Mixes exceed 325 degrees F.</p> <p>Asphalt shall be added to the mineral aggregate at a temperature conforming to the range of temperature specified in Section 711.</p> <p>Thermometric equipment shall be provided to indicate the temperature of the asphalt near the charging valve at the mixer.</p> <p>All scales shall be certified as to accuracy and sealed at least annually by the Sealer of Weights and Measures, and rechecked as ordered by the Engineer. Each scale installation shall be provided with certified weights as follows:</p> <p>The Contractor shall provide not less than 20 certified weights, each weighing 50 pounds, to be used by the Engineer in checking scales used on the project. Each weight shall be numbered and show the corresponding certified weight. The scales and weights shall remain the property of the Contractor and no payment will be made for their use.</p> <p>The asphalt concrete manufacturer shall make whatever alternations are necessary to his equipment to enable the Sealer of Weights and Measures to conveniently check, calibrate, and seal the aggregate and asphalt scales used in production of asphalt concrete.</p> <p>Scales shall be so located that the mixer operator and the plant inspector have an unobstructed close-up view of the indicating or registering devices. They shall indicate the true net weight without the application of any factor. The dial for dial type scales shall not be less than 12 inches in diameter and the figures thereon shall be clearly legible.</p>
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Municipality	Supplements
PH:	<p>Subsection 710.7 BATCH MIXING:</p> <p>710.7.1 General Requirements: The mixer shall be of the twin-shaft pug mill type and shall be operated at the speed recommended by the manufacturer. It shall be equipped with paddles of sufficient size and number to deliver a thorough and uniform mixture. Should the paddles or other parts of the pug mill become worn to such extent as to adversely affect the quality of the mixing or allow leakage from the discharge gate, they shall be promptly replaced.</p> <p>The amount of material that may be mixed per batch shall not exceed the rated capacity of the plant, or that which will permit complete mixing of all the materials.</p> <p>Dead areas in the mixer, in which the material does not move or is not sufficiently agitated, shall be corrected either by a reduction in the volume of materials or by other adjustments.</p> <p>All boxes, hoppers, buckets, or similar receptacles used for weighing mineral aggregate, filler material, and asphalt, as well as all scales used in batching materials shall be insulated against the vibration or movement of the rest of the plant, so that the error in weighing, with the entire plant operating, will not exceed 2 percent for any setting nor 1½ percent for any batch.</p>

	<p>Dial heads or readout devices shall be mounted separate from batch plant or tower supports. This will nullify most vibrations from readout.</p> <p>710.7.2 Aggregate: The aggregate scales shall be either multiple beam or springless dial type having a capacity exceeding 1 ½ times the total amount of materials to be weighed in one operation. Each scale graduation shall be approximately 1/1000 of the total capacity of the scale.</p> <p>710.7.3 Asphalt: For mixers with a manufacturer's rated capacity of 4,000 pounds or less, the asphalt shall be measured by weight in a heated insulated bucket suspended from a springless dial scale system having a capacity of not more than 500 pounds with one-pound gradations. For mixers with a manufacturer's rated capacity of more than 4,000 pounds, the scale system shall have a capacity of not more than 1,000 pounds with one-pound gradations.</p> <p>Asphalt shall be introduced into the mixer by means of a distributing pan fixed to the side of the mixer, by gravity distribution along the center of the mixer parallel to the mixer shafts, or by pressure spraying. The pan shall be equipped with movable vanes in order that the flow of asphalt may be directed across the width of the pan as desired. The vanes shall be equipped with a means of quick adjustment and a positive lock to prevent shifting.</p> <p>710.7.4 Filler Material: Filler material shall be introduced into the mixer through the weight box, or introduced into the center of the mixer.</p> <p>710.7.5 Mixing: The entire batch shall be continuously mixed until all the materials are thoroughly blended into a homogeneous mass. The maximum mixing time for any one batch shall be as hereinafter specified for that particular type mix. The time of mixing a batch shall begin on the charging stroke of the weigh hopper dumping mechanism and shall end when discharge from the mixer has started. The mixer shall be equipped with a time lock mechanism which locks the mixer discharge gate for the mixing period and activates an indicator light, or bell, which shall be used in signaling the end of the mixing time. The time lock and indicator light or lights, shall be actuated by the charging stroke of the weigh hopper charging mechanism. There shall also be provided an interlock and indicator light to provide for the dry mixing time for the introduction of filler which shall be a minimum of 4 seconds and not more than 15 seconds as required by the Engineer. The device shall be accurate to within 2 seconds. The time of mixing shall be not less than 30 or more than 45 seconds, or as otherwise directed by the Engineer. If for any reason the mix cannot be discharged when the mixing cycle is completed, power to the mill shall be cut off or the mix shall be wasted. The mixing shall begin with the introduction of the asphalt into the mixer, and shall end when the mixer gate is opened. When asphalt is introduced by spraying, the spraying time shall not exceed 15 seconds. In any event, mixing shall continue until uniform coating of the aggregate is obtained.</p> <p>The mixer platform shall be of ample size to provide safe and convenient access to the mixer and other equipment. Mixer and weigh-box housing shall be provided with hinged gates of ample size to permit ready sampling of the discharge of aggregates from each of the plant bins.</p> <p>Means shall also be provided for convenient and accurate sampling of the mixture.</p>
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Municipality	Supplements
PH:	<p>710.8 CONTINUOUS MIXING:</p> <p>710.8.1 General Requirements: In addition to the general requirements above specified, continuous mixing of the materials shall conform to the following:</p> <ul style="list-style-type: none"> (A) No asphalt concrete shall be produced until the plant has been calibrated to the satisfaction of the Engineer. When there is a change in the weight per cubic foot of the aggregate, the Engineer may require that the plant be recalibrated. (B) The maximum rate of production at which the plant will be permitted to operate shall not exceed the manufacturer's recommendations.

	<p>710.8.2 Storage Bins: Storage bins shall be equipped with overflow chutes for each compartment. If there is evidence of fine material hanging on the sides of the fine bin, the fine bin shall be equipped with a vibrating unit which will effectively vibrate the side walls of the bin and prevent any hang-up of segregated sizes while the plant is operating. A positive signal system shall be provided to indicate the low level of material in each bin and as the level of material in any on bin approaches the strike off capacity of the feed gate, the device will automatically close down the feed of all materials to the mixer instantly. Unless this automatic signal system is in good working condition, the plant will not be permitted to operate. Openings in the partitions between the bins will not be permitted.</p> <p>710.8.3 Feeder: The correct proportions of each aggregate size and filler material introduced into the mixer shall be drawn from the storage bins by an approved type of continuous feeder, which shall supply the correct amount of aggregate and filler material in proportion to the asphalt, and be so arranged that the proportion of each size can be separately adjusted. The continuous feeder for the aggregate may be mechanically or electrically actuated.</p> <p>Aggregate feeders that are mechanically driven shall be directly connected with the drive on the asphalt pump.</p> <p>Aggregate feeders that are electrically driven shall be actuated from the same circuit that serves the motor driving the asphalt pump. Current for operation of plants equipped with electrically driven feeders shall be actuated from the same circuit that serves the motor driving the asphalt pump. Current for operation of plants equipped with electrically actuated aggregate feeders shall not vary in frequency in excess of one cycle nor in voltage in excess of ten percent. The drive shaft on the feeder shall be equipped with a revolution counter reading to one one-hundredth of a revolution.</p> <p>710.8.4 Asphalt Pump: The asphalt pump shall be a positive displacement type pump. The use of pressure relief valve will not be permitted. The plant shall be equipped with an indicating meter between the pump and spray, and the meter shall be in good working condition and accurately record the gallons of material pumped. All pipe, bins, fittings, and meter shall be steam jacketed or otherwise properly insulated.</p> <p>The asphalt storage system shall be equipped with a device for automatic plant cut-off when the intake of the positive displacement pump is not working under positive pressure.</p> <p>A suitable by-pass shall be installed between the pump and the spray bar to divert the flow of asphalt into a auxiliary container of not less than 25-gallon capacity in order that the Engineer may check the rate of delivery of the pump.</p> <p>710.8.5 Discharge Hopper: The material from the mixer shall be discharged into a hopper in order that segregation of the mixture will be at a minimum. The hopper shall be approved by the Engineer.</p> <p>710.8.6 Facilities for Samplings: Continuous mixing plants shall be equipped with three or more sampling hoppers. These shall be so placed that the discharge from each aggregate feeder may be diverted into each hopper while the feeders are in full operation. The weight of the hoppers shall be determined by means of a springless dial or a beam type scale.</p> <p>The area around the hoppers shall be kept free of all aggregate and debris and the Contractor shall furnish all labor required in handling the hoppers and weighing the materials and in disposing of all excess materials.</p> <p>Means shall be provided for convenient and accurate sampling of the mixture as it leaves the mixer.</p> <p>If the results obtained indicate that uniform proportioning of the aggregate from the bins or uniform and correct amounts of asphalt are not being delivered, the Engineer shall order that operations cease until proper corrections have been made.</p>
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Municipality	Supplements
PH:	<p>Subsection 710.9 DRUM MIXING:</p> <p>710.9.1 General Requirements: The drum mix plant shall be capable of producing a thorough and uniform mixture. The production of the drum mix plant shall be governed by the rate required to obtain a thorough and uniform mixture.</p> <p>No asphalt concrete shall be accepted until the plant has been calibrated to the satisfaction of the Engineer. When tests indicate material produced is not in conformance with the approved job-mix design, no asphalt concrete will be allowed to be used on the job until the plant has been re-calibrated to the satisfaction of the Engineer.</p> <p>710.9.2 Aggregate Delivery System: An automatic plant shut-off shall be provided to operate when any aggregate bin becomes empty. Provisions shall be provided for conveniently sampling the full flow of materials from the total cold feed. Total cold feed shall be weighed continuously. The weighing system shall have an accuracy of 0.5 percent when tested for accuracy. The plant shall provide weight control of the cold aggregate feed by use of a belt scale, or other appropriate device, which will automatically regulate the feed gate and permit instant correction of variations in load. The cold feed flow shall be automatically coupled with the asphalt flow to maintain the required proportions of each material. Provisions shall be made for introducing the moisture content of the cold feed aggregates into the belt weighing signal and correcting wet aggregate weight to dry aggregate weight. Screens or other suitable devices which will reject oversize particles or lumps of aggregate that have been cemented together shall be installed in the feeder mechanism between the bins and the dryer drum.</p> <p>Dry weight of the aggregate flow shall be displayed digitally in appropriate units of weight and time and totaled.</p> <p>710.9.3 Additive Delivery Systems: Satisfactory means of metering shall be provided to introduce the proper amount of additives into the mix. Delivery systems shall prove accurate to plus or minus one percent when tested for accuracy. The additive flow shall be displayed digitally in appropriate units of (weight) and time shall be totaled.</p> <p>710.9.4 Thermometric Equipment: A recording thermometer of adequate range shall be located to indicate the temperature of the bituminous material in storage. The plant shall also be equipped with approved recording thermometers, pyrometers, or other approved recording thermometric instruments at the discharge chute of the drum mixer.</p> <p>710.9.5 Asphalt Delivery System: The drum mixer plant shall be equipped with a positive displacement type asphalt pump and an indicating meter between the pump and spray to monitor the proper amount of asphalt being introduced into the mix when displaced digitally in appropriate units of volume or weight. The asphalt delivery shall be interlocked with the aggregate weight and accurate to plus or minus one percent when tested for accuracy.</p> <p>The asphalt delivery system shall be equipped with a device for automatic plant cut-off when the intake of the positive displacement pump is not working under positive pressure.</p> <p>A suitable by-pass shall be installed between the pump and the spray bar to divert the flow of asphalt in order that the Engineer may check the rate of delivery of the pump.</p> <p>710.9.6 Temporary Storage of Bituminous Mixture: Use of surge bins or storage bins for temporary storage of hot bituminous mixtures will be permitted as follows:</p> <p>The bituminous mixture may be stored in insulated and heated storage bins for a period of time not to exceed 12 hours, provided an inert gas atmosphere is maintained in the bin during the storage period.</p> <p>If the Engineer determines that there is an excessive amount of heat loss, segregation and/or oxidation of the mixture due to temporary storage, use of surge bins or storage bin will be discontinued.</p>

Municipality	Supplements
PH:	<p>Subsection 710.10 GENERAL REQUIREMENTS</p> <p>The temperature indicating device reading to 500 degrees F. and accurate to 5 degrees F. shall be fixed in the asphalt line or storage tank at a suitable location.</p> <p>The temperature of the mixture discharged into the hauling vehicles shall not vary more than 30 degrees F. for successive batches. The discharge end of the asphalt binder circulating pipe shall be maintained below the surface of the asphalt binder in the storage tank to prevent discharging hot bituminous binder into open air. The Contractor shall provide a suitable sampling outlet in the asphalt feed lines connecting the plant storage tanks to the asphalt weighing system or spray bar. The sampling device shall consist of a ½ inch or ¾ inch valve constructed in such a manner that a one-gallon sample may be withdrawn slowly at any time during plant operations. The valve shall be maintained in good condition and if it fails to function properly, it shall be replaced. The sampling device shall be placed in a location that is readily accessible and in an area free of dangerous obstructions. A drainage receptacle shall be provided for flushing the devices prior to sampling.</p> <p>Mixtures shall be delivered to the site of the work without segregation of the ingredients and within the temperature range specified in Section 321.</p> <p>At the time of delivery to the job site, the Engineer shall be provided with a legible weight master's certificate (delivery ticket) containing the following information:</p> <p>(1) Date; (2) Supplier's name; (3) Plant location and/or plant number; (4) Ticket number; (5) Truck number; (6) Contractor's name; (7) Project name and/or location; (8) Product code/description with percent asphalt; (9) Mineral filler/additive and percent; (10) Temperature at batching; (11) Time of batching, arrival and unloading; (12) Material weight or vehicle weight with and without material; (13) Weight of accumulative loads.</p>

PAVING ASPHALT

711.1 GENERAL:

The asphalt shall be produced from crude asphalt petroleum or a mixture of refined liquid asphalt and refined solid asphalt. It shall be free from admixture with any residues obtained by the artificial distillation of coal, coal tar, or paraffin oil and shall be homogeneous and free from water.

Asphalt shall not be heated during the process of its manufacture, storage, or during construction so as to cause injury as evidence by the formation of carbonized particles.

711.2 TESTING REQUIREMENTS:

Paving asphalt shall be classified by the Performance Grading System and shall conform to the requirements set forth in Table 711-1

TABLE 711-1				
PERFORMANCE GRADING SYSTEM				
	PG 64-10	PG 70-10	PG-76-10	PG 82-10
Original Asphalt				
Viscosity, ASTM D4402 (Note 1) Max. 3 Pa-s, Test Temp, °C	135	135	135	135
Dynamic Shear TP5 (Note 2) G*/Sin δ, Min., 1.0 kPa Test Temp. @ 10 rad/s, °C	64	70	76	82
Rolling Thin Film Oven Residue (T240)				
Mass Loss, Maximum % Dynamic Shear TP5 G*/sin δ, Min., 2.20 kPa Test Temp. @ 10 rad/s, °C	1.064	1.07	1.076	1.082
Pressure Aging Vessel Residue (PP1)				
PAV Aging Temperature, °C	110	110	110	110
Dynamic Shear TP5 G*/sin δ, Max., 5000 kPa Test Temp. @ 10 rad/s, °C	31	34	37	40
Creep Stiffness, TP1 (Note 3) S, Maximum, 300.0 Mpa m-value, Minimum, 0.300 Test Temp. @60s, °C	0	0	0	0
Direct Tension, TP3 (Note 3) Failure Strain, Minimum 1.0% Test Temp. @ 1.0 mm/min. °C	0	0	0	0

On all Grades Flash Point Temperature T48: Minimum 230 °C and Mass Loss, Maximum 1.00 percent.

NOTES:

- (1) This requirement may be waived at the discretion of the specifying agency if the supplier warrants that the asphalt binder can be adequately pumped and mixed at temperatures that meet all applicable safety standards.

(2) For quality control of unmodified asphalt cement production, measurement of the viscosity of the original asphalt cement may be substituted for dynamic shear measurements of $G^*/\sin(\delta)$ at test temperatures when the asphalt is a Newtonian fluid. Any suitable standard means of viscosity measurement may be used, including capillary or rotational viscometry (T210 or T202).

(3) If the Creep Stiffness is below 300 Mpa, the direct tension test is not required. If the Creep Stiffness is between 300 and 600 Mpa, the direct tension failure strain requirement can be used in lieu of the Creep Stiffness requirement. The m-value requirement must be satisfied in all cases.

Design Note: Performance Grade Asphalts are selected for certain reliabilities with respect to high and low pavement temperatures. The specified characteristics are based upon a loading frequency that approximates vehicle speeds of approximately 90 km/hr. Since all binders are frequency dependent, the designer may consider increasing the high temperature requirement for slow transient and standing loads, such as intersection loading. The high temperature requirement may also be increased for excessive numbers of equivalent single axle loads.

711.3 TEST REPORT AND CERTIFICATION:

At the time of delivery of each shipment of asphalt, the supplier supplying the material shall deliver to the purchaser 3 certified copies of the test report which shall indicate the name of the refinery and supplier, type and grade of asphalt delivered, date and point of delivery, quantity delivered, delivery ticket number, purchase order number, and results of the above specified tests. The test report shall be signed by an authorized representative of the supplier certifying that the product delivered conforms to the specifications for the type and grade indicated.

Until the certified test reports and samples of the material have been checked by the Engineer, that material will be only tentatively accepted by the Contracting Agency. Final acceptance will be dependent upon the determination of the Engineer that the material involved fulfills the requirements prescribed. The certified test reports and the testing required in connection with the reports shall be at no additional cost to the Contracting Agency.

711.4 TEMPERATURES:

Unless otherwise specified in these specifications or in the special provisions, the various grades of paving asphalt shall be applied within the temperature range indicated in Table 711-2. The exact temperature shall be determined by the Engineer.

At no time, after loading into a tank car or truck for transportation from the refinery to the purchaser, shall the temperature of the paving asphalt be raised above 400 degrees F.

TABLE 711-2				
APPLICATION TEMPERATURE OF PAVING ASPHALTS				
Grade of Material	Pug Mill Mixing Asphalt Temperature °F.		Distributor Application Temperature °F.	
	Min.	Max.	Min.	Max.
PG 64-10	275	325	300	390
PG 70-10	275	325	300	390
PG 76-10	290	340	310	390
PG 82-10	290	340	315	390

Paving asphalt shall be heated in such a manner that steam or hot oils will not be introduced directly into the paving asphalt during heating.

711.5 DISTRIBUTING EQUIPMENT:

Distributing Equipment shall meet the requirements of Section 330.

711.6 CONVERSION OF QUANTITIES:

When pay quantities of paving asphalt are determined from volumetric measurements, the volumetric measurement at any temperature shall be reduced to the volume the material would occupy at 60 degrees F. in accordance with ASTM D-1250. In converting volume to weight, the computations shall be based on Table 711-3.

TABLE 711-3		
PAVING ASPHALT QUANTITY CONVERSION		
Grade of Material	Gals. Per Ton of 60 °F.	Lbs. Per Gal at 60 °F.
PG 64-10	235	8.5
PG 70-10	235	8.5
PG 76-10	230	8.7
PG 82-10	230	8.7

LIQUID ASPHALT

712.1 GENERAL:

Liquid asphalt shall consist essentially of either natural crude or refined asphalt petroleum, or a residual product thereof.

The liquid asphalt shall be medium curing product designed by the letters MC, and shall consist of a paving asphalt conforming to the provisions in Section 711, fluxed or blended with a kerosene type solvent.

The asphalt shall not be heated during the process of its manufacture or during construction so as to cause injury as evidence by the formation of carbonized particles.

712.2 TEST REQUIREMENTS:

The liquid asphalt shall consist of materials specified above and shall conform to the requirements set forth in Table 712-1.

712.3 TEST REPORTS AND CERTIFICATIONS:

Test reports and certifications will be furnished in accordance with Section 711.

712.4 CONVERSION OF QUANTITIES:

When pay quantities of liquid asphalt are determined from volumetric measurements, the volumetric measurement at any temperature shall be reduced to the volume the material would occupy at 60 degrees F. in accordance with ASTM D-1250. In converting volume to weight, the computations shall be based on the data contained in Table 712-2.

TABLE 712-1										
AASHTO —82 TABLE 1										
	MC-30		MC-70		MC-250		MC-800		MC-3000	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Kinematic Viscosity at 60°C (140°F) centistokes	30	60	70	140	250	500	800	1600	3000	6000
Flash point (Tab. open-cup), degrees C° (F)	38 (100)	...	38 (100)	...	66 (150)	...	66 (150)	...	66 (150)	...
Water percent	...	0.2	...	0.2	...	0.2	...	0.2	...	0.2
Distillation test: Distillate percentage by volume of total distillate to 360°C (680°F)										
to 225°C (437°F)	...	25	0	20	0	10
to 260°C (500°F)	40	70	20	60	15	55	0	35	0	15
to 315°C (600°F)	75	93	65	90	60	87	45	80	15	75
Residue from distillation to 360°C (680°F) Volume percentage of sample by difference	50	...	55	...	67	...	75	...	80	...
Tests on residue from distillation:										
Absolute viscosity at 60°C (140°F) poises	300	1200	300	1200	300	1200	300	1200	300	1200
Ductility, 5 cm/min, cm.	100	...	100	...	100	...	100	...	100	...
Solubility in Trichloroethylene, percent	99	...	99	...	99	...	99	...	99	...

TABLE 712-2		
LIQUID ASPHALT QUANTITY CONVERSION		
Grade of Materials	Gals. Per Ton at 60 Degrees F.	Lbs. Per Gals. at 60 Degrees F.
70	253	7.90
250	249	8.03
800	245	8.16
2000	241	8.30

EMULSIFIED ASPHALTS

713.1 GENERAL:

Emulsified asphalts shall be composed of a paving asphalt base uniformly emulsified with water and an emulsifying or stabilizing agent. It shall be homogeneous throughout and if stored, shall show no separation of ingredients within 30 days after delivery. Emulsified asphalt shall be classified as quick setting, rapid setting, medium setting or slow setting type in either anionic or cationic emulsions.

Emulsified asphalt shall be specified as follows:

- (A) Penetration type and high viscosity type emulsion shall be designated by the letters RS-Rapid Setting.
- (B) Mixing type emulsion shall be designated by the letters SS-Slow Setting, MS-Medium Setting and QS-Quick Setting.

713.2 TESTING REQUIREMENTS:

The emulsified asphalt shall conform to the requirements set forth in Table 713-1.

713.3 TESTS REPORT AND CERTIFICATION:

Test reports and certifications shall be made in accordance with Section 711.

TABLE 713-1														
REQUIREMENTS FOR ANIONIC EMULSIFIED ASPHALT (Specification Designation)														
Type	Rapid-Setting				Medium-Setting				Slow-Setting					
	RS-1		RS-2h		MS-1		MS-2		MS-2h		SS-1		SS-1h	
Grade	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Tests on emulsions														
Viscosity, Saybolt Furol at 77°F (25°C.), sec	20	100			20	100	100		100		20	100	20	100
Viscosity, Saybolt Furol at 122°F (50°C.), sec			75	400										
Settlement, 24 hour day, percent		1		1		1		1		1		1		1
Demulsibility, 35 ml. 0.02 N. CaCl ₂ , percent	60		60											
Coating ability and water resistance														
Coating, dry and aggregate					good		good		good					
Coating, after spraying					fair		fair		fair					
Coating, wet aggregate					fair		fair		fair					
Coating, after spraying					fair		fair		fair					
Cement mixing test, percent											2		2	
Sieve test, percent		0.1		0.1		0.1		0.1		0.1		0.1		0.1
Residue by distillation, percent	55		63		55		65		65		57		57	
Tests on Residue from Distillation Test:														
Penetration 77°F (25°C), 100g, 5 s	100	200	40	90	100	200	100	200	40	90	100	200	40	90
Ductility, 77°F (25°C), 5 cm/min. cm.	40		40		40		40		40		40		40	
Solubility in trichloroethylene, %	97.5		97.5		97.5		97.5		97.5		97.5		97.5	

TABLE 713-1 (continued)								
REQUIREMENTS FOR ANIONIC/CATIONIC EMULSIFIED ASPHALT (Specification Designation)								
Type	Quick Setting		Rapid Setting		Medium Setting		Slow Setting	
	QSH	CQSH	CRS-1	CRS-2h	CMS-2	CMS-2h	CSS-1	CSS-1h
Grade	Min Max	Min Max	Min Max	Min Max	Min Max	Min Max	Min Max	Min Max
Tests on emulsions:								
Visc., Saybolt Furol at 77°F., sec.	20 100						20 100	20 100
Visc., Saybolt Furol at 122°F., sec			20 100	100 400	50 450	50 450		
Settlement, 24 hour day, percent			1	1	1	1	1	1
Demulsibility, 35 ml 0.8% sodium dioctyl sulfosuccinate, %			40	40				
Coating ability and water resistance:								
Dry aggregate after spraying					Good	Good		
wet aggregate after spraying					Fair	Fair		
					Fair	Fair		
					Fair	Fair		
Particle charge test	Negative	Positive	Positive	Positive	Positive	Positive	Positive	Positive
Sieve Test, %	0.1	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Cement Mixing test, %							2.0	2.0
Distillation:								
Oil distillate, by volume of emulsion, %			3	3	12	12		
Residue, %	57	57	60	65	65	65	57	57
Test on Residue from distillation test:								
Penetration, 25°C (77°F), 100 g. 5 sec.	40 110	40 110	100 250	40 90	100 250	40 90	100 250	40 90
Ductility, 25°C (77°F.) 5 cm per min, cm.	40	40	40	40	40	40	40	40
Solubility in trichloroethylene, %	98	98	98	98	98	98	97.5	97.5
Storage Stability Test, 1 day, %	1	1						

* If the Particle Charge Test result is inconclusive for CSS-1 and CSS-1h, material having a maximum pil value of 6.7 will be accepted.

713.4 TEMPERATURES:

Unless otherwise specified, the various grades of emulsified asphalt shall be applied at temperatures within the limits specified in Table 713-2 the exact temperature to be determined by the Engineer. Emulsified asphalt shall be reheated if necessary. But at no time, after loading into a tank car or truck for transportation to the work site, shall the temperature of the emulsion be raised above the maximum temperature shown in Table 713-2. During all reheating operations, the emulsified asphalt shall be agitated to prevent localized overheating. Emulsified asphalt shall not be permitted to cool to a temperature of less than 40 degrees F.

TABLE 713-2		
APPLICATION TEMPERATURE OF EMULSIFIED ASPHALT		
Grade of Emulsified Asphalt	Minimum °F.	Maximum °F.
RS-1, MS-1, SS-1, SS-1h, CSS-1, CSS-1h	70°F.	140°F.
RS-2, MS-2, MS-2h, crs-1, CRS-1h, CRS-2h, CMS-2, CMS-2h, QSH, CQSH	125°F.	185°F.

Emulsified asphalt shall be heated in such a manner that steam or hot oils will not be introduced directly into the emulsified asphalt during heating.

713.5 CONVERSION OF QUANTITIES:

When pay quantities of emulsified asphalt are determined from volumetric measurements, the volumetric measurement at any temperature shall be reduced to the volume the material would occupy at 60 degrees F. in accordance with ASTM D-1250. In converting volume to weight, the computations shall be based on Table 713-3.

TABLE 713-3		
EMULSIFIED ASPHALTS QUANTITY CONVERSION		
Grade of Material	Gals Per Ton at 60°F.	Lbs Per Gal. at 60°F.
All grades	240	8.33

SLURRY SEAL MATERIALS

715.1 GENERAL:

Slurry seal shall consist of a properly proportioned mixture of emulsified asphalt, mineral aggregate, mineral fillers, and water.

All material source must be approved prior to their use. The Contractor will submit material samples at least seven days prior to start of construction. When requested, additional samples will be furnished during the construction period at no cost to the Contracting Agency. This is a non-pay item.

Municipality	Supplements
SC:	TABLE 715.1: <i>Make the following revision:</i> For TYPE II Slurry Seal Aggregate, the minimum application rate shall be 17 Pounds of Aggregate per Square Yard.

715.2 AGGREGATE:

715.2.1 Mineral Filler: Mineral filler shall consist of finely divided matter, such as hydrated lime, portland cement, limestone dust or fly ash, conforming to the requirements of ASTM D-4318. Mineral filler shall be used only when needed to reduce the setting time, to improve the workability or to reduce the stripping characteristics of the aggregate emulsion mixture. The minimum amount of the required filler will be used and it will be considered as part of the blended aggregate. The expected range shall be between .25% and 2.0% by weight of aggregate.

715.2.2 Mineral Aggregate: Mineral aggregate shall consist of sound and durable sand and/or crushed stone as per MAG Section 701 combined with an approved mineral filler where it is required. The mineral filler will be considered as part of the blended aggregate. The material shall be non-plastic (ASTM D-4318) with a sand equivalent (ASTM D-2419) of at least 50. The abrasion loss (ASTM C-131) shall not exceed 35 percent. Ninety percent of the aggregate retained on the No. 50 sieve shall have at least one fractured face. The gradation of material aggregate shall conform to Table 715-1.

715.3 BITUMINOUS MATERIAL:

The emulsified asphalt used for seal coating shall be quick setting or slow setting as per Section 713.

The quick setting emulsified asphalt shall be of the anionic or cationic quick set type such as QSH or CQSH that will react to chemically active mineral fillers such as portland cement in such a way that the applied slurry mixture can support controlled traffic in 45-60 minutes after application. The amount of chemically active filler shall be determined by mix design and field performance.

Quick Set Emulsion Mix Properties

Slurry Seal Mixing, 70-85 degree F., Sec.	120 Sec. Min.
Slurry Seal Setting test, 70-85 degree F., 1 hour cure	No Brown Stain
Slurry Seal Water Resistance Test, 70-85 degree F., 30 minute cure	No More Than Slight Discoloration

Slow setting emulsion may be used when traffic control is not a critical item.

Placement of slurry seal is temperature dependent and should be tested under field conditions.

715.4 WATER:

Water shall be potable and be compatible with the slurry ingredients used.

715.5 TEST CERTIFICATES & REPORTS:

Test certificates and reports for the bituminous material shall be furnished in accordance with Section 711.

715.6 CONVERSION OF QUANTITIES:

Volumetric conversions shall be accomplished in accordance with Section 713.

TABLE 715-1			
SLURRY SEAL AGGREGATE			
SIEVE SIZE	Type I % PASSING	Type II % PASSING	Type III % PASSING
38053	100	100	100
No. 4	100	85/100	70/90
No. 8	90/100	65/90	45/70
No. 16	65/90	45/70	28/50
No. 30	40/60	30/50	19/34
No. 50	25/42	18/30	38345
No. 100	15/30	38280	38185
No. 200	38279	38121	38121
Emulsified Asphalt content as a % of Dry Wt. Of Aggregate (approx.) ASTM D-3910 (W.T.A.T. TEST)	18	16	14
Residual Asphalt Range requirements % of Dry Wt. of Aggregate ASTM D-3910 (W.T.A.T. TEST)	38275	7.5-13	6.5-12
Pounds of Aggregate per Square Yard (approx.)	38208	38338	18-25

COVER MATERIAL

716.1 GENERAL:

Cover material “chips” shall consist of precoated or uncoated aggregate spread in conjunction with a bituminous or asphalt-rubber seal coat.

716.2 STONE CHIPS:

716.2.1 General: The stone chips shall be crushed rock as per Section 701 except as modified below.

716.2.2 Tests: The chips' weight loss shall not exceed 40 percent of 500 revolutions where tested in accordance with ASTM C-131.

The chips shall not show a loss in excess of 12 percent when tested in accordance with AASHTO T-104 (Sodium Sulfate Soundness)

A minimum of 75 percent of the material, by weight, retained on the No. 8 sieve, shall have at least one fractured face produced by the crushing operation.

716.2.3 Gradation: When tested in accordance with ASTM C-136 and C-117, gradation shall comply with Table 716-1 and/or Table 716-2.

TABLE 716-1	
COVER MATERIAL (CHIPS) GRADATION For Low Volume Traffic Only	
Sieve Size	Percent Passing
1/2 inch	100
3/8 inch	97/100
1/4 inch	70/100
#8	0-5
#200	0-2

Table 716-2	
COVER MATERIAL (CHIPS) GRADATION For High Volume Traffic	
Sieve Size	Percent Passing
3/4 inch	100
1/2 inch	97/100
3/8 inch	70/100
1/4 inch	0-10
#8	0-5
#200	0-2

716.3 PRECOATED CHIPS:

When specified, the aggregate shall be heated and precoated with asphalt cement as specified in Section 711. The quantity of bituminous material used shall not be less than 0.30 percent or greater than 0.70 percent of the combined weight of the bituminous material and the aggregate.

The final percentage of asphalt used for coating shall be as directed by the Engineer. The precoating shall be done in a pug mill mixing facility for a minimum of 30 seconds or until the asphalt is present on the aggregate, whichever is greater. With approval of the Engineer, a drum mix plant may be used, however, the end result shall produce a uniform, dust free product.

716.4 UNCOATED CHIPS:

When liquid or paving grade asphalt is used as the bituminous binder, the uncoated chips shall not contain moisture in excess of a saturated surface dry condition.

When emulsified asphalt is used as the bituminous binder, the uncoated chips shall be surface wet but free from running water.

ASPHALT-RUBBER

717.1 GENERAL:

Asphalt rubber shall consist of a properly proportioned mixture of hot paving grade asphalt, ground vulcanized rubber and a hydrocarbon diluent combined by heating into a visco-elastic composition.

There are two approved production processes, Method A and Method B. Prior to any placement, the Contractor will provide a certification from the supplier that the asphalt-rubber components conform to the material requirements for either Method A or B.

Municipality	Supplements
MC:	717.1 Description: The work under this section shall consist of furnishing, proportioning and mixing all the ingredients necessary to produce an asphalt-rubber material.

717.2 MATERIAL - METHOD A:

717.2.1 Paving Grade Asphalt: The paving grade asphalt used shall meet the requirement of Section 711.

Municipality	Supplements																								
MC:	<p>717.2.1 Asphalt-Rubber:</p> <p>Asphalt Cement: Asphalt cement shall conform to the requirements of Section 711.</p> <p>Rubber: Rubber shall meet the following gradation requirements when tested in accordance with Arizona Test Method 714. Type B shall be used unless otherwise specified.</p> <table><tr><th>Sieve</th><th colspan="2">Percent Passing</th></tr><tr><th>Size</th><th>Type A</th><th>Type B</th></tr><tr><td>2.36 mm (#8)</td><td>100</td><td></td></tr><tr><td>2.00 mm (#10)</td><td>95 - 100</td><td>100</td></tr><tr><td>1.18 mm (#16)</td><td>0 - 10</td><td>65 - 100</td></tr><tr><td>600 μm (#30)</td><td></td><td>20 - 100</td></tr><tr><td>300 μm (#50)</td><td></td><td>0 - 45</td></tr><tr><td>75 μm (#200)</td><td></td><td>0 - 5</td></tr></table> <p>The rubber shall have a specific gravity of 1.15 ± 0.05 and shall be free of wire or other contaminating materials, except that Type A rubber shall contain not more than 0.1 percent fabric and Type B shall contain not more than 0.5 percent fabric. Calcium carbonate, up to four percent by weight of the granulated rubber, may be added to prevent the particles from sticking together.</p> <p>Certificates of Compliance conforming to Arizona State Department of Transportation Standard Specifications for Road and Bridge Construction Section 106.05 shall be submitted. In addition, the Certificates shall confirm that the rubber is a crumb rubber, derived from processing whole scrap tires or shredded tire materials; and the tires from which the crumb rubber is produced is taken from automobiles, trucks, or other equipment owned and operated in the United States. The Certificates shall also verify that the processing does not produce, as a waste product, casings or other round tire material that can hold water when stored or disposed of above the ground.</p>	Sieve	Percent Passing		Size	Type A	Type B	2.36 mm (#8)	100		2.00 mm (#10)	95 - 100	100	1.18 mm (#16)	0 - 10	65 - 100	600 μm (#30)		20 - 100	300 μm (#50)		0 - 45	75 μm (#200)		0 - 5
Sieve	Percent Passing																								
Size	Type A	Type B																							
2.36 mm (#8)	100																								
2.00 mm (#10)	95 - 100	100																							
1.18 mm (#16)	0 - 10	65 - 100																							
600 μm (#30)		20 - 100																							
300 μm (#50)		0 - 45																							
75 μm (#200)		0 - 5																							

717.2.2 Extender Oil: The extender oil shall be a resinous, high flash point, aromatic hydrocarbon conforming to the following test requirements:

Viscosity, 55 U, at 100 degree F. (ASTM D-88) 2500 min.

Flash point, COC, degrees F. (ASTM D-92) 390 min.

Molecular Analysis (ASTM D-2007):

Asphaltenes, percent by weight 0.0 max.

Aromatics, percent by weight 55.0 min.

Municipality	Supplements
MC:	717.2.2 Asphalt-Rubber Proportions: The asphalt-rubber shall contain a minimum of 20 percent ground rubber by the weight of the asphalt cement.

717.2.3 Ground Vulcanized Rubber: The rubber shall be vulcanized rubber scrap specially selected so that the natural rubber content is at least 25 percent by total weight. It shall be free from fabric, wire or other contaminating material. After grinding, it must be a dry, free-flowing material. Not more than 4 percent by weight of a mineral powder (such as calcium carbonate) may be included to prevent sticking or caking of the particle. The dry, free-flowing ground rubber shall meet the following test requirements of Table 717-1.

TABLE 717-1	
GROUND VULCANIZED RUBBER GRADATION (ASTM) C-136	
Chemical Analysis (ASTM D-297) Natural Rubber Content, percent by weight 25 min.	
Sieve No.	Percent Passing
8	100
30	25-50
50	5-45
100	0-10

Municipality	Supplements																															
MC:	<p>717.2.3 Asphalt-Rubber Properties: Asphalt-rubber shall be Type 1 unless otherwise specified and conform to the following:</p> <table><tr><th rowspan="2">Property</th><th colspan="3">Requirement</th></tr><tr><th>Type I</th><th>Type 2</th><th>Type 3</th></tr><tr><td>Grade of base asphalt cement</td><td>PG 64-16</td><td>PG 58-22</td><td>PG 52-28</td></tr><tr><td>Rotational Viscosity*; 177°C (351°F); Pascal seconds (cps)</td><td>1.5-4.0 (1500-4000)</td><td>1.5-4.0 (1500-4000)</td><td>1.5-4.0 (1500-4000)</td></tr><tr><td>Penetration; 4°C (39°F), 200g, 60 sec. (ASTM D 5); dmm (in), min</td><td>10 (0.04)</td><td>15 (0.06)</td><td>25 (0.10)</td></tr><tr><td>Ductility; 4°C (39°F), 1 cpm (ASTM D 113); cm (in), min.</td><td>5 (2)</td><td>5 (2)</td><td>5 (2)</td></tr><tr><td>Softening Point; (ASTM D 36); °C (°F), min.</td><td>57 (135)</td><td>54 (129)</td><td>52 (126)</td></tr><tr><td>Resilience;25°C (77°F) (ASTM D 3407);%,min</td><td>25</td><td>20</td><td>15</td></tr></table> <p>* The Viscometer used must be a Haake Viscometer, Model VT – 04, Rotor No. 1, or viscometer correlated.</p>	Property	Requirement			Type I	Type 2	Type 3	Grade of base asphalt cement	PG 64-16	PG 58-22	PG 52-28	Rotational Viscosity*; 177°C (351°F); Pascal seconds (cps)	1.5-4.0 (1500-4000)	1.5-4.0 (1500-4000)	1.5-4.0 (1500-4000)	Penetration; 4°C (39°F), 200g, 60 sec. (ASTM D 5); dmm (in), min	10 (0.04)	15 (0.06)	25 (0.10)	Ductility; 4°C (39°F), 1 cpm (ASTM D 113); cm (in), min.	5 (2)	5 (2)	5 (2)	Softening Point; (ASTM D 36); °C (°F), min.	57 (135)	54 (129)	52 (126)	Resilience;25°C (77°F) (ASTM D 3407);%,min	25	20	15
Property	Requirement																															
	Type I	Type 2	Type 3																													
Grade of base asphalt cement	PG 64-16	PG 58-22	PG 52-28																													
Rotational Viscosity*; 177°C (351°F); Pascal seconds (cps)	1.5-4.0 (1500-4000)	1.5-4.0 (1500-4000)	1.5-4.0 (1500-4000)																													
Penetration; 4°C (39°F), 200g, 60 sec. (ASTM D 5); dmm (in), min	10 (0.04)	15 (0.06)	25 (0.10)																													
Ductility; 4°C (39°F), 1 cpm (ASTM D 113); cm (in), min.	5 (2)	5 (2)	5 (2)																													
Softening Point; (ASTM D 36); °C (°F), min.	57 (135)	54 (129)	52 (126)																													
Resilience;25°C (77°F) (ASTM D 3407);%,min	25	20	15																													

Municipality	Supplements
MC:	<p>717.2.4 Asphalt-Rubber Design:</p> <p>At least two weeks Prior to the use of asphalt-rubber, the Contractor shall submit an asphalt-rubber design prepared by an approved laboratory. Such design shall meet the requirements specified herein. The design shall show the values obtained from the required tests, along with the following information: percent, grade and source of the asphalt cement used; and percent, gradation and source(s) of rubber used.</p>

717.3 MATERIAL - METHOD B:

717.3.1 Paving Grade Asphalt: The paving grade asphalt used shall meet the requirement of Section 711.

Municipality	Supplements
MC:	<p>717.3.1 Mixing of Asphalt-Rubber: The temperature of the asphalt-cement shall be between 191°C (375°F) and 218°C (425°F) prior to the addition of rubber. No agglomerations of rubber particles in excess of 2" in the least dimension shall be allowed in the mixing chamber. The ground rubber and asphalt-cement shall be accurately proportioned in accordance with the design and thoroughly mixed prior to the beginning of the one-hour reaction period. Reaction time may be decreased to 45-minutes if documentation is provided that the physical properties of the mix design requirements are consistently met using a 45-minute reaction period. The Contractor shall document that the proportions are accurate and that the rubber has been uniformly incorporated into the mixture. Additionally, the Contractor shall demonstrate that the rubber particles have been thoroughly mixed such that they have been "wetted." The occurrence of rubber floating on the surface or agglomerations of rubber particles shall be evidence of insufficient mixing. The temperature of the asphalt-rubber immediately after mixing shall be between 177°C (350°F) and 204°C (400°F). Reaction time shall start after all of the material for the batch has been mixed and the minimum reaction temperature of 177°C (350°F) has been achieved.</p> <p>Prior to use, the viscosity of the asphalt-rubber shall be tested by the use of a rotational viscometer, which is to be furnished by the Contractor or supplier. The Contractor shall provide a qualified person to perform the testing.</p>

717.3.2 Kerosene:** The kerosene used shall be compatible with the other materials and shall meet the following requirements:

Flash Point - Degrees F. (ASTM D-92)	80 min.
Initial Boiling Point - Degrees F. (ASTM D-850)	350 min.
Dry Point - Degrees F. (ASTM D-850)	450 max.

****WARNING:** Kerosene shall not be used in mix design for asphalt rubber hot mix.

Municipality	Supplements
MC:	<p>717.3.2 Handling of Asphalt-Rubber:</p> <p>Once the asphalt-rubber has been mixed, it shall be kept thoroughly agitated during periods of use to prevent settling of the rubber particles. During the production of asphaltic concrete the temperature of the asphalt-rubber shall be maintained between 163°C (325°F) and 191°C (375°F). However, in no case shall the asphalt-rubber be held for more than 10 hours at these temperatures. It shall be allowed to cool to a temperature of 121°C (250°F) or less and held at that temperature for not more than four days. The process of cooling and reheating shall not be allowed more than one time for a batch of asphalt rubber binder.</p> <p>For each load or batch of asphalt-rubber, the Contractor shall provide the Engineer with the following documentation:</p> <p>(A) The source, grade, amount and temperature of the asphalt cement prior to the addition of rubber.</p> <p>(B) The source and amount of rubber and the rubber content expressed as percent by the weight of</p>

	<p>the asphalt cement.</p> <p>(C) Times and dates of the rubber additions and resultant viscosity test.</p> <p>(D) A record of the temperature, with time and date reference for each load or batch. The record shall begin at the time of the addition of rubber and continue until the load or batch is completely used. Readings and recordings shall be made at every temperature change in excess of 11°C (52°F), and as needed to document other events which are significant to batch use and quality.</p>
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717.3.3 Ground Tire Rubber: The rubber shall be 100 percent vulcanized, ground tire rubber. It shall be free from fabric, wire or other contaminating material. After grinding, it must be a dry, free-flowing material with a specific gravity of 1.15 ± 0.05 . Not more than 4 percent by weight of a mineral powder (such as calcium carbonate) may be included to prevent sticking or caking of the particles. The gradation shall be in accordance with Table 717-2.

TABLE 717-2	
GROUND TIRE RUBBER GRADATION (ASTM C-136)	
Sieve No.	Percent Passing
8	100
10	95-100
30	0-10
50	0-2

PRESERVATIVE SEAL FOR ASPHALT CONCRETE

Municipality	Supplements
ME:	CC. Section 718 Unless otherwise noted on the Plans or Specifications, all Preservative Seals for asphalt concrete pavement shall be Type D in compliance with the test methods and requirements within M.A.G. Section 718.

718.1 GENERAL:

Asphalt concrete preservative seal shall be one of the following types or equal, with typical application rates.

Type A - Petroleum resin-oil base emulsion. Applied at 0.05 to 0.10 gallons per square yard, diluted.

Type B - Petroleum Hydrocarbon emulsion. Applied at 0.05 to 0.20 gallons per square yard, diluted.

Type C - Not Used.

Type D - Acrylic polymer, modified asphalt emulsion. Applies at 0.10 to 0.20 gallons per square yard, diluted as specified by the manufacturer.

718.2 TEST METHODS AND REQUIREMENTS:

Preservative seal shall meet Type A, B, or D on Table 718-1 by certification from the manufacturer.

TABLE 718-1				
PRESERVATIVE SEAL SPECIFICATIONS				
Property and Test Method*3		Type A	Type B	Type D
Saybolt Viscosity @ 77°F SFS	AASHTO T 72	15-40	25-150	15-40 *(1-3)
Residue by evaporation at 138°C	AASHTO T 59	60 Min.	62 Min.	53 Min.
Sieve Test, %	AASHTO T 59	0.10 Max.	0.10 Max.	0.10 Max.
5 Day Settlement	AASHTO T 59		2.0% Max.	5.0% Max.
Tests on Residue From Evaporation AASHTO T 59				
Kinematic Viscosity c.St @ 140EF	ASTM D2170	100-200	1,000-9,500	*(1-3)
Flash Point	ASTM D92	400°F	450°F	450°F
Softening Point, °F	AASHTO T 53			130°Min.
Penetration @77°F 100 g/5 sec., dmm	AASHTO T 49			20-80
Ductility @ 77°F, 5 cm/min, cm	AASHTO T 51			20 Min.
Asphaltenes	ASTM D2007	1.0 Max	10.0 Max	
Maltene Dist Ratio (PC+A ₁)/(A ₂ +S)	ASTM D2007	0.3 - 0.6	0.2 - 1.4	
Saturated Hydrocarbons, S, %	ASTM D2007	28 Max.	28 Max.	
PC/S Ratio		0.5 Min.	0.5 Min.	
Accelerated Weathering Test	ASTM D4799-03			Plant Certification Within 6 Months

*Notes:

- (1) Only residue by evaporation should be run on diluted samples. Specification limits should be diluted rate times minimum residue value of concentrate.
- (2) A full series of tests shall be performed as specified by the special provisions in the undiluted condition and at the expense of the contractor. Otherwise, the agency shall perform any tests at the expense of the agency.
- (3) All testing will be run by AMRL accredited laboratory, accredited in the specific test being run.

RECYCLED ASPHALT CONCRETE HOT MIXED

719.1 GENERAL:

Recycled asphalt concrete (RAC) shall consist of reclaimed asphalt pavement, new aggregate and paving asphalt and/or recycling agent. This mixture shall be combined at a central mixing plant to provide a homogenous, workable product. This product shall meet the requirement of Section 710, based on the type specified, for aggregate gradation, asphalt grade and asphalt content.

Prior to the use of RAC on any project, the Contractor shall notify the Engineer of his intentions and shall make available the test reports required in Section 709 and a mix design as required by this section. Unless written authorization is given by the Engineer, RAC will not be used in the surface course or single course pavement. If the Contractor fails to comply with the above procedures or with the intent of Section 709 and this section, the RAC will be removed and replaced with asphalt concrete at no cost to the Contracting Agency.

When the amount of RAP is 15 percent or less of the total mix, the supplier shall maintain a job mix formula at the plant. The formula shall be based on current test data and approved by the Engineer.

When the amount of RAP to be added is over 15 percent of the total mix, a job mix formula and supporting test data shall be submitted to the Engineer for approval at least 8 working days prior to use. The supporting test data for the RAC shall include the results of tests for stability, swell, and moisture vapor susceptibility. These tests are in addition to the tests for the RAP stockpile specified in Section 709.

After the job mix formula has been approved, the mixing plant designated and the RAP stockpile(s) approved, the Contractor and/or his Supplier shall not change any of the above or utilize additional mixing plants or stockpiles without prior approval of the Engineer.

719.2 MATERIALS:

719.2.1 Aggregate: New aggregate shall conform to Section 710.

719.2.2 Reclaimed Asphalt Pavement: Shall conform to section 709.

719.2.3 Asphalt: New asphalt shall conform to Section 711.

719.2.4 Mineral Filler: Shall be dry hydrated lime or portland cement.

719.2.5 Recycling Agent (RA): Shall comply with Table 719-1.

TABLE 719-1											
RECYCLING AGENTS											
TEST	ASTM Test	RA 5		RA 25		RA 75		RA 250		RA 500	
	Methods	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Viscosity at 140°F. (60°C). CST	D2170 or 2171	200	800	1000	4000	5000	10000	15000	35000	40000	60000
Flash Point, COC. F. (°C) Min	D92	400	(204)	425	(218)	450	(232)	450	(232)	450	(232)
Saturates Wt. % Max	D2007	30		30		30		30		30	
Residue from RTFO Oven Test at 325°F. (163°C)	D2872										
Viscosity Ratio ² Max	—	3		3		3		3		3	
RTFO Oven Weight Change ±, %	D2872	4		3		2		2		2	
Specific Gravity	D 70 or D1298	Report		Report		Report		Report		Report	

(1) The acceptance of any recycling agent is subject to its ability to develop a RAC binder which will comply with the asphalt grade specified.

(2) Viscosity Ratio =
$$\frac{\text{RTFO Viscosity at 140°F, cSt}}{\text{Original Viscosity at 140°F, cSt}}$$

719.3 DEFINITIONS:

- (A) RAP Asphalt is the asphalt content as determined by tests prescribed in Section 709.
- (B) New Binder is the new asphalt and/or recycling agent added to produce RAC.
- (C) RAC Binder is the total asphalt content present in RAC, consisting of RAP asphalt and new binder.

719.4 TEST REQUIREMENTS:

(A) Combined aggregate and RAP, after all processing except the adding of new binder and mineral filler, shall have an unextracted minimum sand equivalent of 50 when tested in accordance with ASTM D-2419 or AASHTO T-176.

(B) The RAC binder shall meet the RTFO residue requirements in Section 711 for the PG grade specified. The viscosity of the RAC binder shall be determined by test performed on the asphalt residue obtained by the Abson-Recovery Method ASTM D-1856 or ADOT Method 511.

(C) The combined grading and RAC binder content shall conform to Section 710. All percentages are based on the weight of dry aggregate only.

719.5 RAC BATCH PLANT METHOD:

A conventional batch plant shall be modified to introduce the RAP at locations other than the dryer by:

- (A) Providing a separate RAP storage facility, with direct access to the weight hopper or

- (B) Providing for RAP introduction to the hot aggregate elevator; or
- (C) Other method approved by the Engineer.

New aggregate shall be dried and heated for a sufficient time in the dryer so that the moisture content will not be greater than 1 percent.

The dryer shall be provided with an approved temperature-indicating device to determine the temperature of the aggregate leaving the dryer. The device shall be mounted independently of other plant components, shall be accurate to the nearest 10 degrees F., and shall be installed in such a manner that a temperature fluctuation of 10 degrees F. in the aggregate will be indicated within 1 minute.

After drying, the aggregates shall be evenly fed to the screens in such quantities as to maintain, in the separate bins, a uniform grading of the materials and a proper balance in the amount of material. The operation of the screens shall be controlled so as to secure a thorough separation of the aggregate sizes.

Each bin shall be provided with an opening to prevent overflow into adjacent bins.

If any time there is a substantial change made in the cold feed to accommodate the demands of a different type of mixture, the hot storage bins shall be emptied and recharged with the correct materials. Discharged materials may be returned to a storage area that contains aggregates of the approximate grading of the discharged material, except when the hot storage bins contain RAP. Discharged material containing RAP shall be returned to a separate stockpile.

719.6 RAC DRIER-DRUM METHOD:

When producing RAC, new aggregate shall be fed indirectly to the mixer at a uniform rate. The RAP shall be introduced into the drier-drum and combined with the hot, new aggregate in such a manner that the RAC is protected from direct contact with the burner flame by means approved by the Engineer. The new binder shall be introduced into the drum after the RAP and the new aggregate have been combined.

A device shall be provided which indicates the temperature of the mixed material leaving the drum. The device shall be accurate to the nearest 10 degree F. and shall be installed in such a manner that temperature changes of 10 degrees F. in the mixed material will be shown within 1 minute.

The burner used for heating the aggregate shall achieve complete combustion of the fuel.

719.7 RAC PROPORTIONING:

719.7.1 RAC Batch Plant Method: When introducing the RAP into the hot aggregate elevator, the conveyors supplying the RAP and new aggregates shall be equipped with belt scales with rate-of-flow indicators to show the rates of delivery of each of these ingredients. The belt scales shall be interlocked to maintain the proper proportion of RAP to new aggregate.

When introducing RAP from a separate storage facility, it shall be fed directly into the weigh hopper.

All materials shall be proportioned by weight. Aggregate scales shall be either a multiple-beam scale, a springless dial-type scale, or a fully automatic solid-state digital strain-gage transducer weighing device having a capacity exceeding 1 1/4 times the total amount of materials to be weighed in one operation. Each scale gradation shall be approximately 1/1000 of the total scale capacity.

New binder shall be weighed by means of a springless dial scale or a fully automatic solid-state digital strain-gage transducer weighing device having a capacity of not more than 500 pounds with 1-pound graduations for mixers with a manufacturer's rated capacity of 4000 pounds or less, and not more than 1000 pounds with 1-pound graduations for mixers with a manufacturer's rated capacity of over 4000 pounds.

When mineral filler is used, it shall be proportioned by weight or volume by a method that uniformly feeds the material within 10 percent of the required amount.

719.7.2 RAC Drier-Drum Method: When producing RAC, the separate conveyor supplying the RAP to the dryer shall be equipped with a belt scale with rate of flow indicator. This belt scale shall be interlocked to maintain the proper proportions of RAP to new aggregate.

New asphalt and RA shall be measured through separate meters calibrated and certified. A pressure indicator shall be installed at each meter and constant pressure shall be maintained. The meter and lines shall be heated and insulated. The storage tanks for new asphalt and RA shall be equipped with a device for automatic plant cutoff when the fluid level in the tank is lowered sufficiently to expose the pump suction line.

The system shall be capable of varying the rates of delivery of the binder. During any day's run, the temperature of the binder shall not vary more than 50 degrees F.

When mineral filler is used, it shall be proportioned by weight or volume by a method that uniformly feeds the material within 10 percent of the required amount.

The feeders for each material in the RAC shall be equipped with devices by which the rates of feed can be determined while the plant is in full operation.

The RAP and the combined new aggregate shall be weighed on separate belt scales. They shall be of such accuracy that, when the plant is operating between 30 percent and 100 percent of belt capacity, the average difference between the indicated weight of the material delivered and the actual weight delivered will not exceed 1 percent of the actual weight for three 2-minute runs. For any of the three individual 2-minute runs, the indicated weight of material delivered shall not vary from the actual weight delivered by more than 2 percent of the actual weight. The actual weight of material delivered shall be determined by a vehicle platform scale or other certified weighing device approved by the Engineer.

The individual belt scales for the RAP and the combined new aggregate, the proportioning meters for the new asphalt and RA, and the other proportioning devices, shall be interlocked so that the rates of feed of the RAP, new aggregate, new asphalt, and RA will be adjusted automatically to maintain the proper proportions. The plant shall not be operated unless this automatic system is operating and in good working condition.

Belt scales and proportioning meters shall be equipped with resettable totalizers, so that the actual weight of asphalt, RA, RAP, and combined aggregates can be determined. The bins containing the mineral filler, if used, shall be equipped with a vibrating unit or other equipment which will prevent any hang-up of material while the plant is operating. Before the quantity of material in any one bin reaches the strike-off capacity of the feed gate, a device shall automatically close down the plant.

When mineral filler is used, a safe and suitable sampling device shall be installed in each feed line or surge tank preceding the proportioning device.

719.7.3 RAC Miscellaneous Requirements: New aggregate consisting of sand, rock dust, and various sizes of aggregates shall be stored separately at the plant and evenly fed to the dryer to ensure a uniform flow of properly combined aggregates. In placing materials in storage or in moving them from storage to the feeder, no method shall be used which may cause segregation, degradation, or the intermingling of different size aggregates. Materials not meeting the gradation requirements shall be discarded or reprocessed to comply with the requirements of Section 710.

PORTLAND CEMENT CONCRETE

725.1 GENERAL:

Portland cement concrete shall be composed of portland cement or portland Pozzolan cement, Pozzolonic Materials, fine and coarse aggregates, water, and, if provided for or allowed, certain admixtures.

All of the materials used for concrete shall be in accordance with these specifications and requirements for the particular material as provided herein.

Weighing and metering devices used for the purpose of proportioning materials shall fulfill requirements as to accuracy and tolerance prescribed by the Weights and Measures Division of the State of Arizona and shall be sealed and certified in accordance with the procedures established by this agency. This certification shall not be over 12 months old and shall be renewed whenever required by the Engineer. When portable plants are set up at a new or temporary location, the scales and scale assembly shall be inspected and certificate issued regardless of the date when the scales were last tested. The Engineer may require the Contractor to run a quick scale check at any time with certified weights furnished by the Contractor and order the scale recertified if necessary.

TABLE 725-1			
CONCRETE CLASSES MINIMUM REQUIREMENTS			
Class of Concrete	Min. Cement Content Lbs. Per Cu Yard	Minimum Compressive Strength (1)	
		at 14 Days psi	at 28 Days psi
AA	600	3200	4000
A	520	2400	3000
B	470	2000	2500
C	420	1600	2000

- (1) As tested in accordance with ASTM C-39. Maximum slump 5 inches when tested in accordance with ASTM C-143.

Class AA concrete shall be used as specified.

Class A concrete shall be used for concrete structures, either reinforced or non-reinforced, and for concrete pavements.

Class B concrete may be used for curbs, gutters and sidewalks.

Class C concrete may be used for thrust blocks, encasements, fill or over-excavation, etc.

Municipality	Supplements
ME:	DD. Subsection 725.2.1 Pozzolonic Materials: Only Class F Pozzolonic material will be permitted in portland cement concrete.

725.2 PORTLAND CEMENT:

Cement to be used or furnished under this specification shall be Portland cement, conforming with the requirements of ASTM C-150, Type II, low alkali, or Portland Pozzolan Cement, conforming with the requirements of ASTM C-595, Type IP (MS), low alkali, except when another type including high early strength is specified in the special provisions or shown on the plans. Type V cement (ASTM C-150) shall be specified in the special provisions for use in concrete which will be exposed to contact with soils or waters containing water soluble sulfates (as S04) in concentration greater than 0.20% by weight of soil or 1500 PPM in solutions. Pozzolonic materials shall not be used as a directly added ingredient in concrete in combination with Portland Pozzolan Cement.

Cement shall be sampled and tested as prescribed in applicable ASTM specifications. The Contractor shall obtain and deliver to the Engineer a certification of compliance signed by the cement manufacturer, identifying the cement and stating that the cement delivered to the batching site complies with those specifications. When requested by the Engineer, the Contractor shall furnish him with 3 copies of said certification. The cost of furnishing tested cement shall be considered as included in the contract bid price and no additional allowance will be made therefore.

When suitable facilities, as recommended by the Concrete Plant Manufacturer's Bureau, and approved by the Engineer, are available for handling and weighing bulk cement, such facilities shall be used. Otherwise the cement shall be delivered in original unopened sacks that have been filled at the mill and bear the name or brand of the manufacturer. The type of cement, and the weight of cement contained in each sack shall be plainly marked thereon.

Cement shall be stored in such manner as to permit ready access for the purpose of inspection and identification, and so as to be suitably protected against damage by contamination or moisture. Should any lot of bulk cement be delivered to the site show evidence of contamination, the Engineer may require that such lot be removed from the site.

A cement shall not be mixed with any other brand or type unless written permission has first been obtained from the Engineer. All cement used in the manufacture of concrete for any individual structure shall be of the same brand unless otherwise approved by the Engineer.

725.2.1 Pozzolonic Materials: Pozzolonic materials to be used in concrete or furnished under this specification shall conform to the requirements of ASTM C-618.

If an approved pozzolonic material is used, 15 percent by weight of the Table 725-1 minimum portland cement requirements shall be replaced. The replacement ratio shall be 1.2 pounds of pozzolan per pound of replaced portland cement. If the class of concrete is not from Table 725-1, the amount of pozzolonic material used will be 17.5 percent of the combined weight of pozzolonic material and portland cement.

Pozzolans shall be sampled and tested as prescribed in ASTM C-618 and ASTM C-311. The Contractor shall obtain and deliver to the Engineer a certification of compliance signed by the Pozzolan supplier identifying the Pozzolan and stating the Pozzolan delivered to the batching site complies with applicable specifications. The cost of furnishing tested Pozzolan shall be considered as included in the contract bid price and no additional allowance will be made therefore.

Pozzolan material shall be handled and stored in the same manner as portland cement. When facilities for handling bulk Pozzolan are not available, the Pozzolan shall be delivered in original unopened sacks bearing the name and brand of the supplier, the type and source of the Pozzolan, and the weight contained in each sack plainly marked thereon.

A Pozzolan shall not be mixed with any other brand or type unless written permission has first been obtained from the Engineer. All Pozzolan used in the manufacture of concrete for any individual structure shall be of the same type, and from the same source unless otherwise approved by the Engineer.

725.3 AGGREGATES:

Aggregates shall be crushed rock or gravel or a combination thereof and sand conforming to the requirements prescribed in Section 701. Prior to the delivery of the aggregates, the Contractor will be required to furnish samples for testing, and shall notify the Engineer as to when and where they will be available. Thereafter, additional required samples shall be furnished at the expense of the Contractor, but the cost of testing and making the grading analysis will be borne by the Contracting Agency. Samples shall be taken by the Engineer or in the presence of the Engineer.

No method which may cause the segregation, degradation or the combining of materials of different grading shall be used.

725.4 AGGREGATE GRADING:

Aggregates for each batch of concrete to be prepared shall be combined from materials separately stored in the various sizes and gradations as prescribed in Section 701. The relative proportions of each aggregate used will be as required to meet the provisions of this specification and will be the responsibility of the Contractor.

Except where the amount of concrete for any one job is 10 cubic yards or less, various sizes of both coarse and fine aggregate shall be proportioned by weight unless permission to do otherwise has first been obtained from the Engineer. Aggregates that are

proportioned by volume shall be measured in containers of known capacity. Regardless of the method employed, either by weight or volume, each individually stored size of aggregate shall be proportioned separately, but not necessarily weighed individually.

The maximum size of the aggregate shall not be larger than one-fifth of the narrowest dimension between forms of the members for which the concrete is to be used, or larger than 3/4 of the minimum clear spacing between reinforcing bars.

725.5 WATER:

The amount of water shall be varied in accordance with the percentage of free moisture in the material and the requirements of the workability of the aggregate.

The equipment for measuring and supplying the water in the mixer shall be so constructed and arranged that the amount of water to be added to the mixture can be measured, in gallons or by weight, positively and that the predetermined quantity of water required can be discharged rapidly in one operation into the mixing drum without dribbling. Tanks or other equipment for measuring and discharging water into the mixer shall be sufficiently accurate that the amount of water delivered to the mixer for any batch shall not vary more than 1 percent from the required quantity. Adequate means for determining and checking the accuracy of the equipment shall be provided and made available to the Engineer at all times.

The water used for mixing with concrete shall be potable and free from oil, vegetable matter and other deleterious substances, and shall conform to the following requirements:

Water for prestressed concrete shall not contain chlorides calculated as sodium chloride in excess of 1,000 parts per million nor sulphates calculated as sodium sulphate in excess of 1,000 parts per million nor any sulphates calculated as sulphate in excess of 1,000 parts per million. Water shall not contain an amount of impurities that will cause a change in the time of setting of portland cement of more than 25 percent nor a reduction in the compressive strength of portland cement mortar of more than 5 percent compared to results obtained with distilled water.

725.6 ADMIXTURES:

Admixtures of any type, except as otherwise specified, shall not be used unless written authorization has been obtained from the Engineer.

If an air-entraining agent is authorized, the amount used will be limited to the extent that the amount of entrained air by volume shall not be more than 6 percent. Air-entraining agents complying with AASHTO M-154 or ASTM C-260 will be permitted as long as strength requirements are met. Any admixture shall be measured accurately by mechanical means into each batch by equipment and in a method approved by the Engineer. Any admixtures used shall be included in the bid price for that item.

Municipality	Supplements
ME:	EE. Subsection 726.1 – Add the following to this subsection: For concrete curbs, sidewalks and driveways, the contractor shall use a liquid membrane conforming with AASHTO M-148, Type 2 (White Pigmented).

725.7 PROPORTIONING:

All proportioning equipment shall comply with the standards of the Concrete Plant Manufacturer's Bureau and the certification requirements of the Arizona Rock Products Association. The proportioning shall consist of combining the specified sizes of aggregates, each stored in a separate bin with cement, Pozzolanic Materials, and water as herein provided. Weigh hoppers shall be charged from bins located directly over the weigh hoppers or from conveyor belts. When conveyor belts are used, there shall be a separate belt for each size of aggregate.

Bulk cement shall be weighed in an individual hopper and shall be kept separate from the aggregates until the batch ingredients are released for discharge. The cement hopper shall be attached to a separate scale for individual weighing.

All Pozzolan that is to be incorporated into the concrete as a separate ingredient shall be weighed. When the cement scales are used for weighing both cement and Pozzolan, the cement shall be weighed first. If separate scales are provided, they shall be accurate to ± 0.3 percent of the scale capacity.

Scales utilized in the proportioning device may be of the springless dial-type or of the multiple-beam type. If the dial-type, the dial shall be of such size and so arranged that it may be read easily from the operating platform.

If the multiple beam-type, the scales shall be provided with an indicator operated by the main beam which will give positive visible evidence of over or under weight. The indicator shall be so designed that it will operate during the addition of the last 400 pounds of any weighing. The over travel of the indicator hand shall be at least 1/3 of the loading travel. Indicators shall be enclosed against moisture and dust.

Weighing equipment shall be as recommended by the Concrete Plant Manufacturer's Bureau and be insulated against vibration or movement of other operating equipment in the plant. When the entire plant is running, the scale reading at cutoff shall not vary from the weight designated by the Engineer more than 1 percent for cement, Pozzolan or Cement Pozzolan, 1 1/2 percent for any size of aggregate, nor 1 percent for the total aggregate in any batch.

When proportioned at a central mixing plant there shall be an approved moisture meter, accurate within 1/2 percent, installed to indicate the moisture in the fine aggregate.

A concrete mix design carrying the producer's designated mix number of the concrete being furnished under these specifications shall be submitted to the Contracting Agency at least once each year. In the event there is any change in the source of material, another mix design shall be submitted.

725.8 MIXING:

Machine mixing will be required in all cases other than those in which it would obviously prove to be impractical; in which latter event hand mixing will be permitted, only to the extent necessary. Regardless of the method employed, mixing shall be commenced as soon as possible after the cement is placed in contact with the aggregates.

The temperature of materials as charged in the mixer shall be such that the temperature of the mixed concrete at the time it is placed in final position does not exceed 90°F. When the atmospheric temperature at the time of placing concrete is less than 40°F the temperature of the concrete, as placed, shall not be less than 60°F.

All concrete mixers shall be of such design and construction, and so operated, as to provide a thoroughly and properly mixed concrete in which the ingredients are uniformly distributed.

725.8.1 Paving and Stationary Mixers: Paving and stationary mixers shall comply with the standards of the Concrete Plant Manufacturer's Bureau and the certification requirements of the Arizona Rock Products Association. They shall be equipped with an accurate automatic timing device so designed and constructed as to lock the discharge lever before aggregate, cement and Pozzolan enter the drum, and release such lever only after the specified mixing time has elapsed. The regulation of the setting of said device shall be under the supervision of the Engineer. Water control equipment as described in this specification shall also be provided with each concrete mixer.

Mixers shall be maintained in proper and serviceable working condition, and any part or portion thereof that is out of order, or becomes worn to such extent as to detrimentally affect the quality of mixing, shall be promptly repaired or replaced.

The proper proportions of aggregate, cement, Pozzolan and water for each batch of concrete shall be placed in the mixer, and shall be mixed for a period of not less than 50 seconds after all such materials are in the drum.

The rotating speed at which the mixer shall be operated shall conform to that recommended by the manufacturer.

The total volume of materials mixed in any one batch shall neither exceed the water level capacity of the mixer nor the manufacturer's catalog rated capacity of the mixer.

725.8.2 Transit Mixers: Transit mixers shall be high quality equipment and meet the requirements of the Truck Mixer Manufacturer's Bureau and the certification requirements of the Arizona Rock Products Association. Ready mix concrete shall comply with ASTM C-94 except as herein specified.

The total elapsed time between the addition of water at the batch plant and depositing the complete mix shall not exceed 90 minutes. Each mixer and agitator shall have attached thereto in a prominent place a metal plate or plates, installed by the manufacturer, on which is plainly marked the capacity of the drum in terms of the volume of mixed concrete and the speed of rotation for the agitating and mixing speeds of the mixing drum or blades.

Each mixer shall have an identification number painted on the truck in such a location that it can be easily read from the batching platform.

The total volume of materials introduced into the mixer for mixing purposes shall not exceed the manufacturer's guaranteed mixing capacity. If the concrete so mixed does not meet the uniformity requirements of this section, the amount of materials charged into the mixer shall be reduced.

The rotation speed at which the mixer shall be operated shall conform to that recommended by the manufacturer.

The total volume of materials mixed in any one batch shall neither exceed the water level capacity of the mixer nor the manufacturer's catalog rated capacity of the mixer.

Each batch of concrete placed in the mixer shall be mixed for not less than 70 nor more than 100 revolutions of the drum or blades, at the speed designated by the manufacturer of the equipment as mixing speed. Additional mixing shall be at the agitating speed designated by the manufacturer of the equipment. The revolving of the drum shall be continuous until the concrete is completely emptied from the drum. Before any portion of the materials for any batch of concrete is placed therein, the drum of the mixer shall be completely emptied of the previously mixed batch.

At the time of delivery to the job site, the Engineer shall be provided with a legible weighmaster's certificate (delivery ticket) which shall contain the following information:

- Date and Truck Number.
- Name of the Supplier.
- Name of the Contractor.
- Specific designation of job (name and location).
- Number of cubic yards in the batch.
- Type of cement.
- Type of Pozzolan, if any.
- Time the transit mixer is loaded.
- Amount of water added at the job site at request of receiver, and his signature or initials.
- Suppliers' mix design code number.
- Type and amount of admixture, if any.
- Serial number of the ticket.

The type, capacity and manner of operation of the mixing and transporting equipment for ready-mix concrete shall conform to the current Standards for Operation of Truck Mixers and Agitators of the National Ready-Mixed Concrete Association and the Truck Mixer and Agitators Standards of the Truck Mixer Manufacturer's Bureau. Water shall not be added to the batch during transit. Additional water may be added at the point of discharge to adjust slump providing the slump after such water addition does not exceed the maximum allowed by these specifications and that water so added is mixed into the batch for a minimum of 30 additional revolutions at mixing speed. Loss of cement mortar during discharge which in the opinion of the Engineer would be of sufficient amount to affect the homogeneity of the concrete will be cause for rejection of the load. The Contractor shall be responsible for all concrete to which water is added at the job site.

725.8.3 Hand Mixed Concrete: Hand mixed concrete shall be prepared on a watertight level platform in batches of not to exceed 1/3 cubic yard each. The required amount of coarse aggregate shall first be spread on the platform in an even and uniform layer, over which the proper proportion of fine aggregate shall then be likewise spread. The combined depth of both such layers shall not be greater than one foot. The required quantity of cement shall then be evenly distributed over the fine aggregate; following which the entire batch shall be turned with shovels at least twice before the water is added. The proper amount of water shall then be uniformly sprinkled or sprayed over the batch, which shall thereafter be returned with shovels not less than 3 times before being removed from the platform.

725.8.4 Drybatched Unmixed Concrete: Should the Contractor elect to use drybatched unmixed concrete, an accurate automatic batch weight recorder shall be provided to record the quantities of cement, aggregate and water batched into the containers; the weight of cement shall be recorded on either a separate charge from the aggregate or on the same chart using a separate needle.

The recorder shall produce an autographic readable record on a visible chart of the weights of each of the materials batched. After batching, the needle on the chart shall return to zero. The chart scale along the ordinate shall be such that the major portion of the chart is used to record the total weights of the aggregates and water, and the cement. The date of batching, the container number and the batching certificate number shall be recorded on the recorder chart at the time of batching. The recorder charts, or copies thereof, shall become the property of the Contracting Agency and shall be submitted upon request.

All drybatched unmixed concrete delivered to the job site shall be stored in containers so constructed that the cement cannot come in contact with the water and aggregate within the container. Any admixture added to powder form shall be added to the cement; added in liquid form, it shall be added to the water.

The contents of the container shall be discharged into a mixer at the job site. Following discharge of the first container into the mixer, the mixer shall be operated at mixing speeds during the discharge of the remaining containers. After the contents of the last container have been discharged into the mixer, the concrete shall be mixed as specified in this specification for transit mixers, and drum or turbine type mixers.

Any spillage of cement, aggregate, water or admixture during the filling, transporting, or the discharging of the container, shall be cause for rejection of the container or the contents of the mixer if any portion of the rejected container is discharged into the mixer.

725.9 LOADING AND TRANSPORTATION OF MATERIALS AND MIXED CONCRETE:

The compartments of trucks or other equipment used for the purpose of transporting proportioned aggregates, bulk cement or mixed concrete, shall be sufficiently high and tight, and otherwise suitably constructed and adequately protected, to prevent loss or leakage of the contents thereof during transit or charging.

725.10 TESTS:

Concrete specimens for compression tests will be taken in the field by a representative of the Engineer in accordance with ASTM C-172 and C-31 or AASHTO T-23, except as noted hereinafter.

Concrete samples shall be taken from the approximate middle 50 percent of the batch in an uninterrupted stream from the chute directly into the wheelbarrow or similar equipment. Where excessive slump is suspected, a controlling slump test may be made from any portion of the batch, except for the approximate 5 percent on each end of the discharge. If excessive slump is verified, at any time, the remainder of the load shall be rejected and removed from the project and a set of cylinders for compressive strength shall be taken from the batch, if any concrete from the batch was placed. The rate of discharge of the batch shall be regulated by the rate of revolutions of the drum and not by the size of the gate opening. Specimens for compression tests shall be stored in the field in accordance with methods approved by the Contracting Agency and protected from vibration and other disturbances, for a minimum of 28 hours and maximum of 76 hours. A maximum storage period would be involved only where weekends or holidays are involved. Cylinders stored in the field for the maximum period shall have the same validity as cylinders that have been stored overnight and brought in the following day.

Not less than 4 cylinder specimens will be made for each 50 cubic yards of each class of concrete with a minimum of 4 specimens for each class placed or not less than 4 specimens for each half-day's pour. Specimens will be tested in a laboratory designated by the Engineer in accordance with ASTM C-39 at the expense of the Contracting Agency.

Two cylinders shall be tested at 14 days. If their strength meets or exceeds the minimum 14-day requirements, the Contracting Agency will accept the concrete. The Engineer may test the other two cylinders at 28 days or discard at 60 days.

If this strength does not meet the 14-day requirement, the Contractor shall schedule and pay for two cores to be taken, on the 29th day, from the area of concrete represented by the cylinders. The Engineer shall be present when the coring is accomplished or additional cores will be required.

The Engineer will test the remaining two cylinders on the 28th day. If this test meets or exceeds the 28-day minimum compressive strength requirement, the Contracting Agency will accept the concrete and the Contractor may cancel the scheduled coring.

If the 28-day cylinder test does not meet the minimum 28-day compressive strength requirement, the cores will be tested in accordance with ASTM C-42 in a laboratory designated by the Contracting Agency. If the cores meet or exceed the minimum 28-day strength, the concrete will be accepted by the Contracting Agency.

If the strength of the 28-day cylinders and the strength of the cores as calculated in accordance with ASTM C-42 are deficient, the Contractor shall remove all of the concrete represented by the failing test specimens with the exception that if the Contractor believes that the deficient concrete was confined to a single batch, he may immediately cut a minimum of 4 additional cores, two on either side of the affected batch. The cores would be compared with the minimum specified compressive strength, for the purpose of defining the confines of the deficient concrete. All coring done to establish this premise would be at the expense of the Contractor. Evaluation of the cores shall be by the Engineer, or by a substitute agent designated by the Contracting Agency, and his decision shall be final.

Municipality	Supplements																						
PH:	<p>25.10 Tests: Change the fourth and fifth paragraphs, first sentences, to read: Two Cylinders shall be tested at 14 days. If their strength meets or exceeds the minimum 28-day requirement the Contracting Agency will accept the concrete.</p> <p>If this strength does not meet the 28-day requirement, the Contractor shall schedule and pay for two cores to be taken on the 29th day, from the area of concrete represented by the cylinders.</p> <p style="text-align: center;">TABLE 725-1 <u>CONCRETE CLASSES MINIMUM REQUIREMENTS</u></p> <table><tr><th rowspan="2">Class of Concrete</th><th rowspan="2">Min. Cement Content Lb. Per Cu. Yard</th><th colspan="2">Minimum Compressive Strength (1)</th></tr><tr><th>* at 14 Days psi</th><th>at 28 Days psi</th></tr><tr><td>AA</td><td>600</td><td>3200</td><td>4000</td></tr><tr><td>A</td><td>520</td><td>2400</td><td>3000</td></tr><tr><td>B</td><td>470</td><td>2000</td><td>2500</td></tr><tr><td>C</td><td>420</td><td>1600</td><td>2000</td></tr></table> <p>* To be used as information only</p>	Class of Concrete	Min. Cement Content Lb. Per Cu. Yard	Minimum Compressive Strength (1)		* at 14 Days psi	at 28 Days psi	AA	600	3200	4000	A	520	2400	3000	B	470	2000	2500	C	420	1600	2000
Class of Concrete	Min. Cement Content Lb. Per Cu. Yard			Minimum Compressive Strength (1)																			
		* at 14 Days psi	at 28 Days psi																				
AA	600	3200	4000																				
A	520	2400	3000																				
B	470	2000	2500																				
C	420	1600	2000																				

725.11 ACCEPTANCE:

Concrete represented by a strength test of at least 95% of the required 28-day compressive strength will be acceptable. All concrete failing to meet this requirement as evidenced by tests of either standard cylinder or drilled core specimens shall be rejected, removed and replaced by the Contractor at the Contractor's expense.

When concrete is accepted on the basis of strength tests of less than 100% of the required minimum 28-day compressive strength, an adjustment in the contract unit price will be made for the quantity of concrete represented by such strength tests in accordance with the following schedule:

Adjustment in Contract Unit Price for Strength Deficiency

Percent of Specified Minimum 28-Day Compressive Strength Attained (Nearest 1%)	Percent of Concrete Unit Price Allowed
100% or greater	100
98-99	90
96-97	85
95	80

CONCRETE CURING MATERIALS

726.1 GENERAL:

Curing materials shall consist of waterproof paper, polyethylene film or liquid membrane-forming compounds which, when applied to fresh concrete, will inhibit moisture loss and reduce temperature rise during the curing period. All curing materials and methods shall be approved by the Engineer prior to use. Wet coverings such as burlap, cotton mats, or other moisture-retaining fabrics also may be used, or may be required by special provisions.

726.2 MATERIALS:

- (A) Waterproof paper, or polyethylene film, shall conform with AASHTO M-171.
- (B) Liquid membrane-forming compounds shall conform with AASHTO M-148. Type 1 compound with either a Class A or Class B vehicle shall be used for concrete structures, except bridge decks. Type 2 compound, with either a Class A or Class B vehicle shall be used for portland cement concrete pavement, bridge decks and approach slabs.
- (C) Burlap cloth made from jute or kenaf shall conform to AASHTO M-182.

STEEL REINFORCEMENT

727.1 GENERAL:

The following specifications set forth the requirements for bar reinforcement, wire reinforcement, and wire mesh reinforcement. The reinforcement shall conform accurately to the dimensions and details indicated on the plans or otherwise prescribed and before being placed in any concrete work, shall be thoroughly cleaned of all loose rust, mill scale, mortar, oil, dirt, or coating of any character, which would be likely to destroy, reduce, or impair its proper binding with the concrete.

No reinforcing steel will be accepted under this specification until it has been approved by the Engineer. When required by the Engineer, the Contractor or supplier shall furnish a spot sample taken on the project and notify the Engineer as to when and where they will be available. Such samples shall be furnished at the expense of the Contractor or supplier, but the cost of any testing that may be required will be borne by the Contracting Agency. Samples shall only be taken in the presence of the Engineer. The Contractor shall furnish 3 certified mill test reports or certificates of compliance for each heat or size of steel which can be clearly identified with the lot. When such information has been furnished, placing of the steel will not be held up until results of spot samples have been received. Unless otherwise specified, all reinforcing steel bars shall be deformed intermediate grade 40 billet steel conforming with ASTM A-615 and the shapes shall conform with ASTM B-670.

In testing bar reinforcement, only the theoretical cross-sectional area will be used in all computations.

Bending of steel shall conform to the requirements of ACI-318.

The various grades of steel shall not be used interchangeably in structures.

Municipality	Supplements
MC:	<p>727.1 General: All reinforcing steel shall be deformed, and conform to the current requirements of AASHTO M 31 (ASTM A 615) – Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.</p> <p>Reinforcing steel bars shall be Grade 60.</p> <p>Revise requirements for the bending of steel to read: Bending of reinforcing steel shall conform to the requirements Section 505.5.2.</p>

727.2 WIRE REINFORCEMENT:

Wire reinforcement shall in all respects fulfill requirements prescribed in ASTM A-82.

Municipality	Supplements
MC:	<p>727.2 Wire Reinforcement: Wire reinforcement shall conform to the current requirements of AASHTO M 32 (ASTM A 82) – Steel Wire, Plain, for Concrete Reinforcement.</p>

727.3 WIRE MESH REINFORCEMENT:

Mesh reinforcements shall conform to ASTM A-185. The gage of the wire and the dimension of the mesh will be specified in the special provisions or shown on the plans. The wire mesh reinforcement shall be so constructed as to retain its original shape and form during necessary handling. The effective cross-sectional area of the metal shall be equal to that specified or indicated on the plans.

Municipality	Supplements
MC:	<p>727.3 Wire Mesh Reinforcement: Wire mesh reinforcement shall conform to the current requirements of AASHTO M 55 (ASTM A 185).</p>

727.4 WIRE TIES:

Wire for ties shall be black, annealed, not lighter than 16 gage.

CONTROLLED LOW STRENGTH MATERIAL

728.1 GENERAL:

Controlled Low Strength Material (CLSM) is a mixture of portland cement, aggregate and water that, as the cement hydrates, forms a soil replacement. CLSM is a self-compacting, flowable, cementitious material that is primarily used as a backfill or structural fill in lieu of compacted fill or unsuitable native material.

728.2 MATERIALS:

Portland Cement shall conform to Section 725.2.

Coarse and fine aggregates shall conform to Section 701.

Water shall conform to Section 725.5.

728.3 PROPORTIONING OF MIXTURES AND PRODUCTION TOLERANCES:

Proportioning of the mixture shall comply to Section 701.3.5, Section 725.7 and Table 728-1. A mix design shall be submitted with test data for the Engineer's approval prior to the excavation for which the material is intended for use.

TABLE 728-1			
CONTROLLED LOW STRENGTH MATERIAL REQUIREMENTS			
Description of CLSM	Cement Content, lbs/cu yd	Slump, inches	Compressive Strength at 28 days, psi 1/2
1/2 Sack CLSM	47±5%	7±1	70±30
1 Sack CLSM	94±5%	7±1	150±50
1 1/2 Sack CLSM	141±5%	7±1	425±75

Notes for Table 728-1:

- The values specified in the table are for both mix design requirements and field production. The deviations are for production, testing and sampling tolerances.
- Slump shall be tested in accordance with ASTM C-143. Flow consistency test can be substituted for the slump test. When used, the CLSM shall have a flow consistency of 8 inches as tested in accordance with ASTM D-6103.
- Compressive strength shall be tested in accordance with ASTM D-4832. The supplier shall provide laboratory and/or field test data to verify the design strength.
- Sampling shall be in accordance with ASTM D-4832.
- Unit weight shall be obtained by ASTM D-6023.
- Temperature shall be taken in accordance with ASTM C-1064.
- Cement content shall be tested in accordance with ASTM D-5982.

Where CLSM is to be used as backfill around gas pipelines (totally encapsulating the gas pipeline), the material shall meet a minimum permeability coefficient (k) of 1×10^{-5} cm/sec or more, based on ASTM D-5048.

728.4 MIXING:

The total elapsed time between the addition of the water and placement of the complete mix shall not exceed 90 minutes. The Engineer may waive this limitation if the slump is such that the material can be placed without addition of water.

Mixing shall continue until the cementitious material and water are thoroughly dispersed throughout the material. Mixes shall be homogenous, readily placeable and uniformly workable. Proportioning of ingredients shall produce consistency, durability, workability and other required properties appropriate for the intended usage. When the CLSM is mixed other than at the project site, the mixing shall comply with Section 725.8. When the CLSM is mixed at the job site, the Contractor will submit for the Engineer's approval, the methods, equipment and procedures for proportioning and mixing of the material.

EXPANSION JOINT FILLER

729.1 PREMOLDED JOINT FILLER:

Expansion joint filler materials shall consist of premolded strips of a durable resilient compound and comply with ASTM D-1751, D-1752, or D-2628, as specified by the Contracting Agency.

729.2 POUR TYPE JOINT FILLERS:

Pour type joint fillers shall comply with ASTM D-1850, D-1190, D-1854, or with the following formulation, as specified by the Contracting Agency.

Asphalt latex joint filler shall consist of asphalt latex emulsion and sodium fluosilicate furnished in separate containers and mixed on the site. The emulsion shall consist by volume of 60 parts AR-1000 asphalt conforming to the requirements of Section 711, 40 parts of synthetic latex, GRS-Type 4, and 5 to 10 parts of sodium fluosilicate, half strength. The emulsion and sodium fluosilicate shall not be mixed until the joint is ready to be filled. The amount of sodium fluosilicate to be mixed with the emulsion shall be approximately 3 to 5 percent by weight of the emulsion. The joint to be filled shall be thoroughly cleaned and surface dry.

The sealing compound shall consist of paving asphalt, Grade AR-1000 conforming to the provisions of Section 711, emulsified with rubber latex in the presence of a suitable emulsifying agent. Rubber latex designated as GRS-Type 4, or any other approved type, containing approximately 40 percent solids.

The resulting emulsion shall consist of a minimum of 55 percent of paving asphalt and a minimum of 36 percent of rubber latex and shall conform to the requirements set forth in Table 729-1.

TABLE 729-1			
ASPHALT-LATEX EMULSION JOINT SEALING COMPOUND-			
SPECIFICATION DESIGNATION	TEST METHOD	LIMITS	REMARKS
Furol Viscosity at 77°F.	AASHTO T-72	50-250 seconds	Before adding gelling agent.
Sieve Test	AASHTO T-59	1% Max.	Before adding gelling agent.
Penetration at 77°F.	ASTM D-217	50-250	The penetration test is made on a specimen prepared by stirring 5% of sodium fluosilicate into the asphalt latex emulsion in a 6 ounce deep ointment can. The specimen is then allowed to stand in the air at a temperature of 77°F. ±2° for a period of 30 minutes and is then penetrated with a grease cone under a total load of 150 grams.
Elasticity		70% Min.	After addition of 5% of sodium fluosilicate and curing for 24 hours at 100°F. ±2°, the specimen shall have an elastic recover of not less than 70%.
Dehydration		Loss 30% maximum	Twenty-five grams of emulsion, prior to adding the gelling agent, is placed in an 8 ounce flat ointment can and dehydrated in a suitable oven maintained at a temperature of 200°F. ±2° for a period of 24 hours.
Time of Set		15-60 minutes	After mixing the emulsion with 1% to 4% by weight of powdered sodium fluosilicate the emulsion shall harden or develop a set in from 16 to 60 minutes, under field conditions.

729.3 TEST REPORT AND SHIPMENT CERTIFICATE:

Each shipment shall be accompanied by a certificate in triplicate from the supplier that the material will comply with the above specifications and such certificate shall be delivered to the Engineer. The certificate shall show the shipment number for the entire lot of material contained in the shipment and shall also show a list which will enable the Engineer to identify each individual container by the supplier's batch number, with which each container shall be plainly marked.

729.4 APPLICATION:

At no time shall emulsion types be subjected to a temperature below 40°F. Prior to application, the material may be warmed, if necessary, to permit proper pouring of the joints. The method of heating shall be carefully controlled to avoid overheating of any part of the container or mixture and under no circumstances shall emulsions be heated to a temperature greater than 130°F.

Joints and cracks shall be thoroughly cleaned by hand or mechanical means immediately in advance of pouring the filler material. When new pavement has been cured by the Pigmented Sealing Compound Method, the joints and cracks shall be thoroughly scrubbed by means of a wire brush or a cloth mop saturated with gasoline or by other approved means.

All joints and cracks shall be surface dry before application of the joint sealer. No sealer shall be placed during unsuitable weather or when the atmospheric temperature is below 50°F., or when weather conditions indicate that the temperature may fall to 32°F within 24 hours.

The joints and cracks shall be filled in a neat and workmanlike manner by means of a cornucopia pot or other approved method.

REINFORCED CONCRETE PIPE

735.1 GENERAL:

These specifications cover reinforced concrete pipe and related structures intended to be used for conveyance of sewage, industrial waste, storm and irrigation water.

The size, type, and D-load of the concrete pipe to be finished shall be as shown on the plans, or as specified under the item of work for the project of which the pipe is a part and shall be for pipe installed by the open-cut method of construction.

When specified in the special provisions, four sets of pipe line layout drawings shall be furnished to the Engineer prior to the manufacture of the concrete pipe. Catch basin connector pipe need not be included in the pipe line layout; however, pipe stubs shall be included. In lieu of including catch basin connector pipe in the pipe layout, a list of catch basin connector pipes shall accompany the layout. The connector pipe list shall contain the following information.

- (A) Size and D-load of pipe.
- (B) Station at which pipe joins main line.
- (C) Number of section of pipe, length of section, type of sections (straight, horizontal bevel, vertical bevel, etc.).

The pipe layouts will be used by the Contracting Agency for reference only, but their use shall in no way relieve the Contractor of the responsibility for the correctness of the layout.

(D) All pipe installed in tunnels shall be ASTM C-76, Class III. Pipe stronger than that specified may be furnished at the Contractor's option, and at no additional cost to the Contracting Agency, provided such pipe conforms in all other respects to the applicable provisions of these specifications.

Whatever struts or other protective methods proved necessary to furnish and install the pipe to meet the limitation of cracks as specified herein, shall be provided and maintained throughout pipe handling and transportation.

735.2 QUALITY:

Reinforced concrete pipe shall be manufactured and tested in conformance with the requirements of ASTM C-76, except as modified herein.

All reinforced concrete pipe less than 36 inch inside diameter shall include an area of reinforcing steel in the bell not less than the area required for the circumferential reinforcement in the wall of the pipe.

735.3 CURVES, BENDS AND CLOSURES:

Horizontal and vertical long-radius curves shall be formed by bevel adapters or by beveling the straight pipe joint. The bevel of the pipe shall not exceed 5 degrees and the total angular deflection, for beveled pipe, shall not exceed 10 degrees. Small angular changes may be made with straight pipe provided that the joint opening does not exceed 3/4 inch. Short radius curves and closures shall be formed with fabricated specials; however, the angular deflection of any segment of the fabricated section shall not exceed 10 degrees.

735.4 MATERIALS:

Except when otherwise permitted by the Engineer, no materials other than water, portland cement, Pozzolanic materials, mineral aggregates and steel shall be used in the manufacturing of the pipe, conforming to ASTM C-76, with the following exceptions:

(A) Portland Cement: Portland cement shall comply with ASTM C-150, Type II, low alkali. The pipe manufacturer shall supply a cement mill certificate in triplicate for each load of cement delivered, showing the specification, type, chemical analysis, and quantity. In lieu of the above, on stockpiled pipe the manufacturer shall certify that the type of cement used meets this specification. The pipe manufacturer shall also certify in writing that the cement content of the concrete complies with the specifications as to yield per cubic yard of concrete poured.

(B) Pozzolan Materials: Pozzolan materials shall conform to Subsection 725.2.1 and ASTM C-618. If an approved Pozzolan material is used, 17.5 percent of the combined weight of Pozzolan materials and portland cement shall be Pozzolan material.

(C) Mixture: The proportion of portland cement or combination of portland cement and Pozzolan material in the mixture shall not be less and 564 lbs. per cubic yard of concrete.

(D) Concrete Admixtures: The pipe manufacturer shall certify in writing that no calcium chloride or admixture containing calcium chloride has been used in the manufacture of the pipe. Other admixtures may be used if approved by the Engineer. The pipe manufacturer shall certify to the brand and chemical content of such admixtures used.

(E) Steel Reinforcement: The pipe manufacturer shall supply 3 copies of mill certificates showing heat numbers, chemical analysis, and physical tests on reinforcing steel. In lieu of the above, on stockpiled pipe the manufacturer shall certify that the type of steel used meets this specification. The number of steel wraps shall not be less than 5 percent below that shown on the shop drawing for any one pipe.

(F) Rubber Gaskets shall comply with Section 765.

Municipality	Supplements
PH:	<p>35.4 Materials: Paragraph (D) Steel Reinforcement. Change the last sentence that reads "The number of steel wraps . . . for any one pipe." to read:</p> <p>The area of steel used shall be the same as that shown on the shop drawing for that pipe.</p> <p>35.4 Materials: Paragraph (E). Delete this paragraph in its entirety and substitute the following:</p> <p>(E) Rubber gaskets for pipe used for storm sewers, drainage or irrigation purposes shall be in accordance with MAG Section 618.2. Rubber gaskets for sanitary sewer pipe shall be in accordance with MAG Section 765.</p>

735.5 MANUFACTURER'S QUALIFICATIONS AND EQUIPMENT REQUIREMENTS:

The manufacturer shall be competent to manufacture the type, size and quality of pipe; in addition, he shall have satisfactory curing and storage facilities, and satisfactory financial resources.

Calibration of Cement and Aggregate Scales: The pipe manufacturer shall make whatever alterations are necessary to his equipment to enable the Contracting Agency's Sealer or State Inspector of Weights and Measures to check, calibrate, and seal the aggregate and cement scales used in the pipe production.

735.6 CURING OF PIPE:

(A) Steam Curing: The manufacturer shall provide adequate steam plant, piping, enclosures, and other facilities for curing the pipe. The enclosures shall be such that the temperature is maintained continuously between 110 and 150°F.

(B) Curing of the pipe shall not commence until the concrete has attained its initial set, but in any event not sooner than 1 hour nor later than 8 hours after placing of the concrete. Rate of rise of temperature shall not exceed 30°F per hour.

(C) Water Curing: The pipe shall be kept moist during daylight hours. The pipe, including the ends, shall be covered with burlap for the first 3 days, except that, if the pipe is kept constantly and completely wet with fog sprays during the daylight hours, the burlap covering may be omitted. If the manufacturer fails to proceed immediately with the required water curing he shall seal the

surfaces of the concrete, except joint surfaces that are to be grouted, with an approved, white pigmented sealing compound in accordance with Section 726.

735.7 TESTS AND ACCEPTANCE:

(A) Basis of Acceptance: The basis of acceptance for the reinforced concrete pipe shall be in accordance with ASTM C-76 by the method stated in the special provision and as amended herein. However, the purchaser may, at his option, make concrete cylinder tests for the purpose of determining release dates for shipment of the pipe and for his information in regard to general quality of the concrete.

(B) Segregation of Material: The slump of the concrete mix shall not exceed 4 inches so as to preclude excessive segregation of the materials used and shall be proportioned so that the result shall be a homogeneous concrete mixture of such quality that the pipe will conform to the tests and design requirements of these specifications.

(C) A pipe has failed the D-load test when the opening crack exceeds .01 inch for a distance of 1 foot when measured at close intervals. These measurements are taken within the 1 foot measured span only when the crack line is more or less parallel to the axis of the pipe, as it is obvious that where the crack deviates substantially from parallel, and approaches a direction normal to the axis, that the edges of the crack tend to slip past each other, instead of opening up under load. The intent of the test is to measure the crack opening under stress.

(D) Porous or honeycomb concrete areas 6 inches or less in diameter may be removed and repaired. Pipe having defects or repairs greater than 6 inches in diameter will not be accepted.

(E) Any crack exceeding 1 foot in length that goes completely through the pipe, is not considered acceptable whether repaired or not, except that a single end crack that does not exceed the depth of the joint as measured from the end to the inside shoulder is acceptable.

(F) Any crack that is .01 inch in width for one-sixteenth inch in depth or deeper, for a length of 1 foot or more and continues as a hairline crack down to the reinforcing steel for over 1/2 the length of the pipe is not considered acceptable whether repaired or not.

(G) A single continuous hairline crack which does not extend to the reinforcing steel and not in excess of .01 inch in width for a distance of 1 foot is acceptable without repair. This type of crack, longer than 1 foot shall be repaired.

(H) Repairs shall be made by filling the defect with epoxy under pressure or by chipping out a V-section to the full depth of the defect and repairing with an approved patching compound. The composition of the patching compound shall be furnished to the Engineer for approval.

(I) The words regarding acceptability and repairability in the above paragraphs shall also apply when the crack occurs after loading of the pipe in the trench with backfill. Cracks wider than .01 inch shall be assumed to indicate overstress of the steel. In such case, the defective portion of the installation shall be replaced or repaired in a manner acceptable to the Engineer. After structural repairs are completed, the remaining cracks shall be filled as required above. All corrective measures shall be at the expense of the Contractor.

(J) Blisters: All pipe joints having blisters involving less than 1/4 the interior surface area shall be repaired by removing all loose material and exposing all hollow area and replacing with fresh concrete properly bonded, with an acceptable bonding agent, and curing the repair with membrane coating. Blisters with larger areas are not considered to be repairable or acceptable.

(K) Painting of pipe, or portion of pipe, with grout to cover defects, minor or major, will not be permitted until approved by the Engineer.

(L) Where the modified or special design method, under ASTM C-76 is elected, acceptance on the basis of material tests and inspection of manufactured pipe for defects and imperfections shall be as stated in ASTM C-76, and as amended herein. However, one joint of each size and D-load shall be selected by the Engineer for test purposes, and shall be tested for strength by the 3 edge bearing method, ASTM C-497, with the results being used for confirmation of the submitted design for this D-load. If the pipe section tested fails in compression or shear before reaching the D-load specified, the test shall be considered a failure. Additional sections of the same diameter size and class shall be tested as specified above until the load requirements are met for the D-load

strength. This test procedure shall be accomplished only once per manufacture regardless of the number of contractors he supplies. Placing of reinforcing steel in the test section of pipe to control shear cracks will not be permitted.

Requirements regarding defects shall be the same as stated above for standard pipe.

Concrete test requirements specified under compression tests of ASTM C-76 shall be amended in part to read as follows: "The average of any 5 consecutive strength tests of the laboratory-cured specimens shall be equal to or greater than the specified strength set forth in Tables III, IV, or V, and not more than 20 percent of the strength tests shall have values less than the specified strength. If more than 20 percent have values less than the specified strength, the lot represented shall be considered to be defective and not acceptable. In no case shall any cylinder tested fall below 80 percent of the specified design strength. If any one cylinder falls below 80 percent of the specified design strength, then the entire production represented by that cylinder will not be accepted for purchase by the Contracting Agency unless the Contractor can demonstrate by coring to the satisfaction of the Engineer, that the cylinder in question is not representative of the entire production, or is representative of only a portion of the entire production."

During the fabrication of the pipe, concrete cylinders shall be made from a representative sample of the concrete. Concrete cylinders and slump tests shall be made by the Engineer or under his direct supervision. A set of cylinders shall consist of three. A minimum of one set shall be made for each day's production.

In vibrated and spun pipe, where the slump of the concrete approaches 0, the cylinders shall be made as follows:

Fill the cylinder can in 3 equal layers. Each layer shall be vibrated and assisted by rodding or other mechanical contrivance simultaneously until the moisture comes to the surface. Care shall be taken that the material is not over-vibrated which will cause segregation. When the moisture rises to the surface of the third layer, it is struck off and leveled. The cap is put on the cylinder and it is marked for identification. It shall then be steam cured in the same manner as the pipe, at the conclusion of which, the cylinders shall be brought into the laboratory for standard moist curing until the prescribed time for the compressive test.

The cylinders shall be made according to ASTM C-31 where the pipe is manufactured with concrete that has enough slump for the material to be hand rodded. For reinforced concrete pipe made by the centrifugal method, the manufacturer may substitute centrifugally cast test cylinders for standard test cylinders. Centrifugally cast cylinders shall be made in accordance with AWWA C302 and cured in the same manner as normal test cylinders, except that the net area of the hollow cylinder will be used to determine the compressive strength.

735.8 DOWNGRADING OF PIPE:

For the purpose of these specifications, downgrade pipe shall be defined as pipe which is to be used under loads less than that for which they have been designed.

735.9 SANITARY SEWER PIPE:

In addition to the above, sewer pipe shall meet the requirements of ASTM C-76, reinforced concrete pipe having O-ring Rubber Gasket Joints with an interior lining of plastic liner plate in accordance with Section 741.

(A) Pipe Design: The wall thickness and the amount of circumferential reinforcement shall not be less than that required for the D-load indicated on the plans and required by the specifications. The calculations for wall thickness and amount of steel area per foot of pipe, having concrete lining, shall be for a pipe 2 inches larger in internal diameter than that specified on the plans. The additional concrete lining shall not be considered in the calculation for the area of steel required, nor in any of the load calculations.

D-load class of pipe and the date poured shall be plainly marked inside each pipe section. Specific approval must be obtained, prior to submitting a bid, to decrease the cover over the reinforcing steel at the joint should the steel interfere with the rubber gasket in the groove at the spigot end.

(B) Pipe Construction: Tamped or packer head pipe will not be allowed. Pipe having concrete lining shall have the internal diameters indicated on the plans, measured to the inside of the additional 1 inch of covering. The various sizes of pipe shall be centrifugally spun. Pipe having plastic liner plate shall be vibrocast to 1/2 inch tolerance to match the unlined pipe of the D-load indicated on the plans.

(C) Test and Acceptance: In addition to the statements above, any crack that goes completely through the pipe, regardless of length of crack is not considered acceptable whether repaired or not, except that a single end crack that does not exceed the depth of the joint as measured from the end to the inside shoulder is acceptable.

735.10 ACCEPTANCE MARK:

The Engineer may, at the place of manufacturer, indicate his acceptance of the pipe for delivery to the job by marking the pipe with the Contracting Agency's mark. Such acceptance, however, shall not be considered a final acceptance.

If the pipe is subsequently rejected, the mark placed thereon by the Engineer shall be defaced.

NON-REINFORCED CONCRETE PIPE

736.1 GENERAL:

The size and classes of the non-reinforced concrete pipe to be furnished shall be as shown on the plans, or as specified under the item of work for the project of which the concrete pipe is a part.

Strength classes of non-reinforced concrete shall be as identified in ASTM C-14, Class 1 non-reinforced concrete pipe, Class 2 non-reinforced concrete pipe, or Class 3 non-reinforced concrete pipe.

Unless otherwise specified, Class 3 non-reinforced concrete pipe will be used.

Municipality	Supplements
SC:	<p>736.1 GENERAL: <i>Add the following paragraph to this section.</i></p> <p>Prefabricated non-reinforced concrete pipe shall not be allowed for use as a storm drain or culvert material unless specifically approved by the Engineer and by the Transportation Department.</p>

736.2 MATERIALS:

Materials used in manufacturing the pipe shall be as specified in ASTM C-14, with the following exception:

Cement shall conform to ASTM C-150, Type II, low alkali. Samples and testing shall conform to the methods designated therein. The pipe manufacturer shall supply a cement mill certificate, in triplicate, for each load of cement delivered, showing the specification, type, chemical analysis, and quantity. On stockpiled pipe in lieu of the above, the manufacturer shall certify that the type of cement used meets this specification. Satisfactory facilities shall be provided for identifying, inspecting, and sampling cement at the mill, the warehouse, and the site of the work. The Contracting Agency shall have the right to inspect the cement and obtain samples for testing at any of these points. The cement shall be stored in a weathertight, dry, well ventilated structure approved by the Engineer. Cement salvaged by cleaning cement sacks, mechanically or otherwise, shall not be used in the work. Cement containing lumps will be rejected and shall immediately be removed from the site of the work. If the temperature of the cement exceeds 150°F., it shall be stored until cooled to that temperature.

736.3 PIPE JOINTS:

The joints may be tongue and groove mortared joints, or similar to R-4 or modified R-4 Bureau of Reclamation Through-Bell type joints using O-ring rubber gaskets. With rubber gasket joints, inside mortaring and outside grouting is not required. Tongue and groove joints shall be mortared inside and grouted outside. Grouting of outside joints shall be by the diapering method.

Municipality	Supplements
PH:	<p>36.3 Pipe Joints: Delete the first paragraph in its entirety. The specification for pipe joints is included in the City of Phoenix Supplement to Section 618.</p>

736.3.1 Cement Mortar Joints:

(A) The mortar or grout shall consist of 1 part portland cement and 2 parts sand, by volume. The quantity of water in the mixture shall be sufficient to produce a soft workable mortar, but shall in no case exceed a water-cement weight ratio of 0.53. Where outside joints are made by the diaper method, the grout shall be composed of 1 part cement to 3 parts sand, and shall be mixed to the consistency of thick cream. The sand shall conform to Section 701, and the cement shall conform to Section 725.

(B) The pipe ends shall be thoroughly cleaned and wetted with water before the mortar or grout is placed. No backfilling around the joints shall be done until the joints have been fully inspected and approved.

(C) Mortar joints shall be cured by keeping them wet for 3 days or by using a curing compound.

736.3.2 Rubber Gasket Joints: Rubber gaskets shall comply with Section 765.

Municipality	Supplements
PH:	36.3.2 Rubber Gasket Joints: Rubber gaskets shall conform to MAG Subsection 618.2.

736.4 CURVES, BENDS AND CLOSURES:

Horizontal and vertical long-radius curves shall be formed by slight deflection at the joints, provided that the maximum joint opening caused by such deflection shall not exceed 3/4 inch. Short radius curves shall be formed by straight pipe in which the joints are beveled. The bevel of the pipe shall not exceed 5 degrees, and the total angular deflection for beveled pipe shall not exceed 10 degrees at any joint.

736.5 CARE OF PIPE AND MATERIALS:

All pipe and materials shall be manufactured, handled, loaded, shipped and unloaded in such manner as to be undamaged and in sound condition, in the completed work. Particular effort shall be exercised to protect the ends of pipe. Repairs on damaged pipe shall be made to the satisfaction of the Engineer, otherwise they shall not be used in the work and shall be replaced with an equal pipe or special in an acceptable condition. At all times rubber gaskets shall be stored in a cool, dark place until ready for use.

736.6 TESTS:

Before pipe is delivered to the job site for use in any work under the contract, test pipes shall meet the requirements of the hydrostatic pressure test and the loading test described in ASTM C-14. The test shall be made at the point of manufacturer and shall be made under the presence of the Engineer.

ASBESTOS-CEMENT PIPE AND FITTINGS FOR STORM DRAIN AND SANITARY SEWER

737.1 GENERAL:

This specification covers storm drain and sanitary sewer pipe for conveying storm water and sewage in nonpressure pipe for gravity flow systems. Pipe, couplings and fittings shall conform to:

- (A) Storm Drain: ASTM C-663, Type I.
- (B) Sanitary Sewer: ASTM C-428, Type II and lined as specified below.

Municipality	Supplements
SC:	737.1 GENERAL: <i>Add the following paragraph to this section.</i> Asbestos-cement pipe shall not be allowed for use as a storm drain or culvert material unless specifically approved by the Engineer and by the Transportation Department.

737.2 CLASSES:

All asbestos-cement storm drain and sanitary sewer pipe shall be designated as either Class 1500, 2400, 3300, 4000, or 5000 based upon the respective crushing strength for which it is designated and tested. Pipe and fittings shall be furnished in the size and class designated on the plans.

737.3 LENGTH OF PIPE:

At least 90 percent of the total pipe of any one size and class, excluding short lengths, shall be in standard lengths. The remaining pipe may be in random lengths of not less than 7 feet, however, short lengths for making connections to manholes or other structures are permitted as indicated in Table 737-1.

Pipe directly connected to or supported by rigid structures shall not have a length beyond the rigid support provided by the structure in excess of that shown in Table 737-1. Such structures include manholes and foundation walls and cradles. This length limitation need not apply (full length may be used) if a flexible joint is provided at the point of juncture and the pipe from that point does not rest on the structure.

TABLE 737-1	
ASBESTOS-CEMENT PIPE LENGTHS	
Pipe Size	Allowable Length of Pipe
6"	3'-3"
8"-24"	6'-6"
30"-36"	13'-0"

737.4 COUPLINGS:

Couplings shall conform to the same physical requirements as for the class of pipe with which they are to be used. Storm drain couplings may be plastic collars sized to fit the machined end of the pipe and composed of a plastic conforming to ASTM D-1248, Type II, Grade 3.

737.5 FITTINGS:

Asbestos-cement storm drain and sewer pipe wyes, tee, elbows or other fittings shall conform to the same physical requirements as for the class of pipe with which they are to be used.

737.6 RUBBER RINGS:

Each asbestos-cement coupling shall have 2 joint sealing rings conforming to the requirements of ASTM D-1869. This material specification shall also apply to the rings furnished for use with fittings.

- (A) Storm drain pipe shall have synthetic or natural rubber rings, where resistance to oil or solvents is not required.
- (B) Sanitary sewer pipe shall have synthetic rubber rings, where resistance to oil or solvents is required.

737.7 INSPECTION AND TESTING:

The uncombined calcium hydroxide in the asbestos-cement pipe, fittings and couplings shall not exceed:

- (A) Three percent for storm drains
- (B) One percent for sanitary sewers

When tested in accordance with ASTM C-500. Certified copies of all tests shall be submitted to the Engineer for each lot of pipe furnished.

In addition the Contracting Agency may require all inspection and testing to be performed in the United States of American at the manufacturer's plant or at a testing laboratory approved by the Contracting Agency.

737.8 SANITARY SEWER PIPE LINING:

Asbestos-cement pipe and fittings used for sanitary sewers shall be lined with an epoxy resin base of 100 percent solids content (solvent free) with a minimum lining thickness of 32 mils. The lining and its application shall conform in all other respects to ASTM C-541 and NSF Criteria C-7.

HIGH DENSITY POLYETHYLENE PIPE & FITTINGS FOR STORM DRAIN & SANITARY SEWER

738.1 GENERAL:

This specification covers the requirements of profile-reinforced and corrugated (Type S or Type D) high density polyethylene (HDPE) pipe manufactured per ASTM F-894, AASHTO M-252 or AASHTO M-294 for gravity flow, low pressure storm drain and sanitary sewer systems. When noted on the plans or in the special provisions, gravity flow, low pressure storm drains and sanitary sewers may be constructed using HDPE pipe. The HDPE pipe will be of the sizes 8 inch diameter through 120 inch diameter. For the purpose of this specification, low pressure is defined as the test pressures of 3.5 psi of air or 4 feet of water as specified in Section 615.10.

All pipe joints shall conform to the controlled pressure test of 10.8 psi of air or 25 feet of water as stipulated in ASTM D-3212.

The size and class of the HDPE pipe to be furnished shall be designed by the Engineer and shown on the plans or in the project specifications. At no time will the class designed be less than RSC-63 for profile pipe, or minimum equivalent Pipe Stiffness (PS) for corrugated pipe per the requirements of AASHTO M-252 or AASHTO M-294.

Municipality	Supplements
MC:	Section 738.1 is modified as following: HDPE pipe size shall be limited to sizes 8-inch through 60-inch diameter. Sizes greater than 60-inch diameter shall not be used within Maricopa County rights-of-way without specific approval from MCDOT.

Municipality	Supplements
SC:	738.1 GENERAL: This specification covers the requirements of corrugated high density polyethylene (HDPE) pipe manufactured per AASHTO M-252 (4"-10") (Type S), M-294 (12"-48") (Type S), and the AASHTO Interim Specification for smooth interior/smooth exterior (54"-60") (Type S or D) pipe for gravity flow storm drains and sanitary sewer systems. The HDPE pipe will be in sizes (4"-60") as shown on the plans. Written approval for the use of HDPE pipe shall be obtained from the Transportation Planning Division for storm sewers and culverts.

738.2 MATERIALS:

Municipality	Supplements
SC:	738.2 MATERIALS: 738.2.1 Base Material Composition: Pipe base material shall be made from HDPE plastic compounds meeting the requirements of cell classification PE 335420C or higher cell classification in accordance with ASTM D-3350. 738.2.2 Other Pipe Materials: Materials other than those specified under Base Materials shall comply with AASHTO M-294 or M-252. 738.2.3 Gaskets: Rubber gasket shall be manufactured from rubber, synthetic elastomer or a blend of both and shall comply with the physical requirements of ASTM F-477 for water tight joints. 738.2.4 Thermal Welding Material: The HDPE material used for thermally welding the pipe materials shall be compatible with the base material. 738.2.5 Lubricant: The lubricant used for assembly shall comply to the manufacturers recommendations and have no detrimental effect on the gasket or pipe.

738.2.1 Base Material Composition: Profile pipe base material and fittings shall, in accordance with ASTM F-894, be made from a PE plastic compound meeting the requirements of Type III, Class C, Category 5, Grade P34 as defined in ASTM D-1248 and with established hydrostatic design basis (HDB) of not less than 1250 psi for water at 73.4 degrees F. as determined in accordance with Method ASTM D-2837. Materials meeting the requirements of cell classification PE 334433 C or higher cell classification, in accordance with ASTM D-3350 are also suitable. Corrugated pipe base material shall comply with the requirements of AASHTO M-252 (Type S) or AASHTO M-294 (Type S or D) and have a minimum cell classification PE 335420C.

738.2.2 Other Pipe Materials: Materials other than those specified under Base Materials shall comply with ASTM F-894, AASHTO M-252 or AASHTO M-294.

738.2.3 Gaskets: Rubber gaskets shall be manufactured from a natural rubber, synthetic elastomer or a blend of both and shall comply in all respects with the physical requirements in ASTM F-477.

738.2.4 Water Stops: Water stops shall be manufactured from a natural or synthetic rubber and shall conform to the requirements of ASTM C-923. The water stop shall have expansion rings, a tension band, or a take-up device used for mechanically compressing the water stop against the pipe.

738.2.5 Thermal Welding Material: The material used for thermally welding the pipe material shall be compatible with the base material.

738.2.6 Lubricant: The lubricant used for assembly shall comply to manufacturer's recommendations and have no detrimental effect on the gasket or pipe.

738.3 JOINING SYSTEMS:

738.3.1 Gasket Type: Joints for the piping system and fittings shall consist of an integrally formed bell and spigot gasketed joint. The joint shall be designed so that when assembled, the elastomeric gasket located on the spigot is compressed radially on the pipe or fitting bell to form a water tight seal. The joint shall be designed so to prevent displacement of the gasket from the joint during assembly and when in service. The elastomeric gasket shall meet the provision of ASTM F-477.

All pipe shall have a home mark on the spigot end to indicate proper penetration when the joint is made.

The bell and spigot configurations for the fittings shall be compatible to those used for the pipe.

Joints shall provide a seal against exfiltration and infiltration. All surfaces of the joint upon which the gasket may bear, shall be smooth and free of any imperfections, which would adversely affect sealability.

The assembly of the gasketed joints shall be in accordance with the pipe manufacturer's recommendations.

Municipality	Supplements
SC:	<p>738.3.1 Joint Type: Joints for pipe and fittings shall be either a) an integrally formed bell and spigot gasketed joint; b) a thermo-molded coupling gasketed joint; or c) an externally corrugated gasketed coupling for soil tight applications.</p> <p>Joints a) and b) shall provide a seal against exfiltration and infiltration under low pressure. For the purposes of this specification, low pressure is defined as twenty-five (25) feet of water column or less for ASTM F-894 pipe and five (5) feet of water column or less for AASHTO designated pipe. All surfaces of the joint upon which the gasket may bear shall be smooth and free of any imperfections which could adversely affect sealability.</p> <p>The assembly of the gasketed joints shall be in accordance with the manufacturer's recommendations. All pipe using joints a) and b) above shall have a homing mark on the spigot end to indicate proper penetration when the joint is assembled.</p>

738.3.2 Thermal Weld Type: The pipe ends shall consist of an integrally formed bell and spigot, with or without the elastomeric centering gasket, which join together to form an interface between bell and spigot, such that it is suitable to seal by thermal weld using the extrusion welding process, in accordance with the manufacturer's recommended procedure.

Thermal welded joints may be effected by welding from inside the pipe or outside, or both.

The assembly of the welded joints shall be in accordance with the manufacturer's recommendations.

Thermal welded joints shall be used only when specified on plans or in specifications.

738.4 FITTINGS:

Fittings for HDPE profile wall or corrugated pipe may include tees, elbows, manhole adapter rings, plugs, caps, adapters and increasers. Fittings shall be joined by gasket type or thermal weld type joints in accordance with Subsection 738.3.

A clamp gasket or approved method shall be provided at manhole entry or connection to reduce infiltration and exfiltration. Where precast manholes are used, entrance holes must be large enough to allow for proper grouting around the manhole gasket. A non-shrink grout shall be used for grouting.

Municipality	Supplements
SC:	738.4 FITTINGS AND MANHOLES: Fittings for corrugated HDPE pipe may include tees, wyes, elbows, plugs, caps, adapters, and reducers. Fittings shall be joined in accordance with Section 738.3. A waterstop gasket shall be provided on any manhole entry or connection to reduce infiltration and exfiltration. Where precast manholes are used, entrance hole must be large enough to allow for proper grouting around the gasket. A non-shrink grout shall be used for grouting.

738.5 CERTIFICATION:

The manufacturer shall furnish an affidavit (certification) that all materials delivered shall comply with the requirements of ASTM F-894 or AASHTO M-252.

Pipe and resin producers that manufacture according to AASHTO M-294 shall be certified according to the Plastic Pipe Institute protocol for their Third Party Certification Program.

Municipality	Supplements
SC:	738.5 CERTIFICATION: The manufacturer shall furnish a certification that all materials delivered shall comply with the requirements of AASHTO M-252 or M-294 or the Interim AASHTO Specification for corrugated smooth interior/exterior 54 inch and 60 inch HDPE pipe. The certification shall be provided to the Transportation Planning Division in the case of storm sewer or culvert pipe or the Water Resources Department in the case of sanitary sewer pipe.

738.6 DIMENSIONS AND TOLERANCES:

Profile wall HDPE pipe dimensions shall comply with dimensions given in Table 1 of ASTM F-894. The “average or nominal inside diameter” of profile wall HDPE pipe shall not deviate from its normal pipe size by more than as specified in Table 1 of ASTM F-894. Corrugated HDPE pipe dimensions shall be “nominal inside diameter” dimensions and shall not deviate from its nominal pipe size by more than the minimum and maximum tolerances as described in AASHTO M-252 or AASHTO M-294, Section 7.2.3.

Profile pipe shall have a Ring Stiffness Constant (RSC) or Pipe Stiffness (PS) as shown on the plans. The minimum RSC for profile HDPE pipe shall be RSC-63. The minimum PS for corrugated pipe shall be as shown in AASHTO M-252 (Section 7.5) or AASHTO M-294 (Section 7.4), and tested per ASTM D-2412. In no case shall the minimum PS be less than the equivalent PS value for RSC-63.

Municipality	Supplements																								
SC:	<p>738.6 DIMENSIONS AND TOLERANCES:</p> <p>Pipe dimensions shall comply with the dimensions given in AASHTO M-252, M-294, or the Interim Specifications for corrugated smooth interior/exterior 54 inch and 60 inch HDPE pipe. Pipe not complying with the specified tolerances shall be marked with paint on its interior and exterior and immediately removed from the project site.</p> <p>The minimum pipe stiffness shall comply with the following:</p> <table><tr><th>Diameter (inches)</th><th>Minimum Pipe Stiffness (psi)</th><th>Diameter (inches)</th><th>Minimum Pipe Stiffness (inches)</th></tr><tr><td>12 or less</td><td>50</td><td>36</td><td>22</td></tr><tr><td>15</td><td>42</td><td>42</td><td>20</td></tr><tr><td>18</td><td>40</td><td>48</td><td>18</td></tr><tr><td>24</td><td>34</td><td>54</td><td>14</td></tr><tr><td>30</td><td>28</td><td>60</td><td>12</td></tr></table>	Diameter (inches)	Minimum Pipe Stiffness (psi)	Diameter (inches)	Minimum Pipe Stiffness (inches)	12 or less	50	36	22	15	42	42	20	18	40	48	18	24	34	54	14	30	28	60	12
Diameter (inches)	Minimum Pipe Stiffness (psi)	Diameter (inches)	Minimum Pipe Stiffness (inches)																						
12 or less	50	36	22																						
15	42	42	20																						
18	40	48	18																						
24	34	54	14																						
30	28	60	12																						

738.7 CLASSIFICATIONS:

HDPE profile-reinforced pipe products shall be made in four standard Ring Stiffness Constant (RSC) classifications, 40, 63, 100 and 160. These are referred to as RSC-40, RSC-63, RSC-100 and RSC-160. The RSC test shall be conducted in accordance with ASTM D-2412 with the exceptions listed in accordance with ASTM F-894. HDPE corrugated pipe (Type S or Type D) shall meet the minimum Pipe Stiffness (PS) requirements of AASHTO M-252 or AASHTO M-294. The PS test shall be conducted in accordance with ASTM D-2412 with the exceptions listed in accordance with AASHTO M-252 or AASHTO M-294.

Municipality	Supplements
SC:	<p>738.7 CARE OF PIPE AND MATERIALS:</p> <p>Pipe that is gouged, marred, or scratched forming a clear depression shall not be installed and shall be removed.</p>

738.8 MARKINGS:

Markings on pipe shall be per ASTM F-894, AASHTO M-252 or AASHTO M-294. These markings shall be clearly shown on the pipe at intervals of approximately 12 feet and include but not limited to the following: the manufacturer's name or trademark, nominal size, the specification designation, plant designation code, date of manufacture or an appropriate code. All fittings shall be marked with the designation number of the specification and with the manufacturer's identification symbol. In addition, manufacturers of corrugated HDPE, AASHTO M-294, shall print on or affix the appropriate Plastic Pipe Institute Program Mark on each length of pipe produced that meets the requirements of the program.

738.9 CARE OF PIPE AND MATERIALS:

Care of pipe materials shall comply with Subsection 736.5.

HDPE profile reinforced RSC type pipe in shipping or storage shall not be stacked higher than three rows for pipes 21 inches in diameter or less, nor higher than two rows for pipes 24 to 36 inches in diameter inclusive. Pipe shall not be stacked, shipped, or stored with weight on the bells of the pipe.

Corrugated HDPE pipe in shipping and storage shall be stacked per manufacturer's recommendation, but in no case higher than 5 rows for pipe 24 inches or less in diameter, or 3 rows for pipe greater than 24 inches in diameter.

Pipe that is gouged, marred, or scratched forming a clear depression shall not be installed and shall be removed if damaged in the installation.

LINING FOR REINFORCED CONCRETE SANITARY SEWER PIPE

741.1 GENERAL:

The interior area of the reinforced concrete pipe as indicated on the plans, shall be sealed and protected with lining, as specified below.

The installation and application of the pipe lining shall be accomplished by the supplier of the reinforced concrete pipe.

All work for and in connection with the installation of lining in concrete pipe and the field sealing of joints shall be done in strict conformance with all applicable published specifications, instructions and recommendations of the approved lining manufacturer. The pipe supplier shall furnish all labor, material and equipment to successfully accomplish the lining.

Municipality	Supplements
PH:	<p>741.1 General:</p> <p>The interior area of the reinforced concrete pipe as indicated on the plans shall be protected with lining, as specified below.</p> <p>The installation and application of the pipe lining shall be accomplished by the supplier of the reinforced concrete pipe.</p> <p>All work for and in connection with the installation of lining in concrete pipe and the field welding of joints shall be done in strict conformance with all applicable published specifications, instructions and recommendations of the approved lining manufacturer.</p>

741.2 MATERIALS:

741.2.1 Material Composition: The material shall be a liner plate which is a combination of inert, synthetic resins, pigments, and plasticizers, compounded to make permanently flexible sheets.

The liner plate shall be resistant to the following: Oxidizing agents, sulfuric, phosphoric, nitric, chromic, oleic, and stearic acids; sodium and calcium hydroxides; ammonia, sodium, calcium, magnesium, and ferric chlorides; ferric sulfate, petroleum oils and greases; vegetable and animal oils, fats, greases and soaps.

Liner plate shall be impermeable to sewage gasses and liquids and shall be nonconductive to bacterial or fungus growth. All liner plates shall be factory checked electrically to insure freedom from any porosity with a high voltage holiday detector set at a minimum of 20,000 volts.

Joint strips and welding strips shall have the same composition and corrosion resistance as liner plate, but shall not have locking extensions.

The lining shall have good impact resistance, shall be flexible and shall have an elongation sufficient to bridge up to 1/4 inch setting crack which may take place in the pipe or in the joint after installation, without damage to the lining.

Once cast into the pipe, the lining shall be permanently and physically attached to the concrete by a locking extension and shall not rely on an adhesive bond.

Municipality	Supplements
PH:	<p>41.2.1 Material Composition:</p> <p>The material shall be a liner plate which is a combination of inert, synthetic resins, pigments, and plasticizers, compounded to make a permanently flexible sheet.</p> <p>The liner plate shall be resistant to the following: Oxidizing agents, sulfuric, phosphoric, nitric, chromic, oleic, and stearic acids; sodium and calcium hydroxides; ammonia, sodium, calcium, magnesium, and ferric chlorides; ferric sulfate, petroleum oils and greases; vegetable and animal oils, fats, greases and soaps that normally occur in sanitary sewers.</p>

	<p>Liner plate shall be impermeable to sewage gasses and liquids and shall be nonconductive to bacterial or fungus growth. All liner plates shall be factory checked electrically to insure freedom from any porosity with a high voltage holiday detector set at a minimum of 20,000 volts.</p> <p>Joint strips and welding strips shall have the same general composition and corrosion resistance as liner plate, but shall not have locking extensions.</p> <p>The lining shall have good impact resistance, shall be flexible and shall have an elongation sufficient to bridge up to a ¼ inch settling crack which may take place in the pipe or in the joint after installation without damage to the lining.</p> <p>Once cast into the pipe, the lining shall be permanently and physically attached to the concrete by locking extensions and shall not rely on an adhesive bond.</p>
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741.2.2 Material Details and Dimensions: The liner plate shall not be less than 0.065 inches in thickness. Locking extension shall be of the same material as the liner and shall be integrally extruded with the sheets. If steel bands are used to secure the liner plate to the forms transversely, strap channels shall be integrally molded into the sheet.

Liner plate shall be supplied as pipe size sheets fabricated by shop welding together the basic size sheets.

Joint straps shall be 4 inches \pm 0.25 inches in width and shall have each edge beveled prior to application.

Welding strips shall be 1 inch \pm 0.125 inch in width and shall have the edges beveled at time of manufacture.

The Contractor shall submit a shop drawing showing liner plate details for approval by the Engineer, prior to fabrication of the pipe.

Municipality	Supplements
PH:	<p>41.2.2 Material Details and Dimensions:</p> <p>The liner plate shall not be less than 0.065 inches in thickness. Locking extension shall be of the same material as the liner and shall be integrally extruded with the sheets. If steel bands are used to secure the liner plate to the forms transversely, strap channels shall be formed by removing the locking extensions as required.</p> <p>Liner plate shall be supplied either as pipe size sheets or tubes and fabricated by shop welding together using the di-electric welding process. Tensile strength measured across the shop welded joint shall be in accordance with ASTM D412 using Die B and shall be at least 2000 PSI.</p> <p>Joint strips shall be 4-inches \pm 0.25 inches in width and shall have each edge beveled prior to application.</p> <p>Welding strips shall be 1-inch \pm 0.125 inch in width and shall have the edges beveled at time of manufacture.</p> <p>The Contractor shall submit a shop drawing showing liner plate details for approval by the Engineer, prior to fabrication of the pipe.</p>

741.3 Installation of Liner Plate: The installation of liner plate, including the welding of all joints, shall be done in accordance with the manufacturer's recommendations. Nailing through the plate will not be tolerated. Liner plate shall be installed with locking extensions parallel with the longitudinal axis of the sewer, unless otherwise shown on the plans. All joints between individual sheets or sections of liner plates shall be continuously heat-welded by the use of welding strips of the same kind and equivalent thickness of material as the liner plates (with the exception of the integral extension ribs).

Liner plate shall be held snugly in place against inner forms by means of light gage steel wire, light steel banding straps or other suitable means. If steel banding straps are used, they shall be applied in strap channels provided for this purpose.

Locking extensions (T-shaped) shall be integrally extruded to all lower, terminal or longitudinal edges of liner plate as applied to concrete pipe. If banding straps are used, a steel rod 1/4 inch in diameter may be inserted in each locking extension along the longitudinal edges of each sheet of liner plate for concrete pipe or some other approved method for holding the lower edge of the liner plate snugly against the form shall be provided.

Concrete poured against liner plate shall be compacted in a careful manner so as to protect the liner plate and to produce a dense, homogeneous concrete securely anchoring the lock extensions into the concrete.

In removing forms, care shall be taken to protect liner plate from damage. Sharp instruments shall not be used to pry forms from lined surfaces. All holes and cut, torn or seriously abraded areas in the liner plate shall be patched. Patches made entirely with welding strip shall be fused to the liner plate over the entire patch. Larger patches may consist of smooth liner plate applied over the damaged area with adhesive. All edges must be covered with welding strip fused to the patch and the sound liner plate adjoining the damaged area.

The Contractor shall take all necessary measures to prevent damage to installed liner plate from equipment and materials used in or taken through the work.

The applied lining shall be free from bubbles due to poor workmanship, and the Contractor shall cut out said bubbles and weld a similar sheet in place of the bubble, unless otherwise directed by the Engineer.

Application on Concrete Pipe-Special Requirements: Liner plate shall be set flush with the inner edge of the bell or groove end of a pipe section and shall extend to the spigot or tongue end or to approximately 3 inches beyond the tongue end, depending upon the type of liner plate to be made with the adjoining concrete pipe.

Wherever concrete pipe, which are protected with liner plate, join structures not so lined, such as brick structures, concrete pipe, cast-in-place structures or clay pipe, the liner plate shall be extended over and around the end of the pipe and back into the structure for not less than 4 inches.

Where a pipe spur, not of plastic lined concrete, is installed through lined concrete pipe, the liner plate shall be returned 4 inches at the surface of contact. The seal between the liner plate and the spur shall be made using an approved adhesive material and strapped in place.

If the joint space is too wide or the joint space surface too rough to allow satisfactory sealing with this adhesive, the joint space shall be filled with 2 inches of densely caulked lead wool or other approved caulking material.

Lined concrete pipe may be cured by standard curing methods. Care shall be exercised, in handling, transporting and placing lined pipe to prevent damage to the liner plate. No interior hooks or slings shall be used in lifting pipe. All handling operations shall be done with an exterior sling or with a suitable fork lift.

No pipe with damaged lining will be accepted until and unless the damage has been repaired to the satisfaction of the Engineer.

Municipality	Supplements
PH:	<p>741.3 Installer Qualifications:</p> <p>The application of joint strips, weld strips and plastic liner to forms and other surfaces is considered to be specialized work. Personnel performing such work shall be adequately trained in the methods of liner installation and shall demonstrate their ability to the Engineer prior to commencing work.</p> <p>Each welder shall pass an approved qualification welding test before doing any welding. Certification shall be renewed on an yearly basis and the list of qualified personnel shall be maintained by the pipe manufacturer. All test welds shall be made in the presence of the Agency's representative and shall consist of the following:</p> <ol style="list-style-type: none"> 1) Two pieces of liner at least 15-inches long and 9-inches wide, shall be lapped 1 ½-inches and held in a vertical position. 2) A welding strip shall be positioned over the edge of the lap and welded to both pieces of liner. Each end of the welding strip shall extend at least 2-inches beyond the liner to provide tabs. <p>The weld sample shall be tested by the Engineer as follows:</p> <ol style="list-style-type: none"> 1) Each welding strip tab, tested separately, shall be subjected to a 10-pound pull normal to the face of the liner with the liner secured firmly in place. There shall be no separation between the welding strip and liner 2) Three test specimens shall be cut from the welded sample and the weld shall be tested for tensile strength in accordance with ASTM D412 using Die B. Tensile strength measured across the welded joint shall be at least 2000 PSI. <ol style="list-style-type: none"> a) If none of these specimens fails when tested as indicated above, the weld will be considered as satisfactory. b) If one specimen fails to pass the tension test, a retest will be permitted. The retest shall consist of testing three additional specimens cut from the original welded sample. If all three of the retest specimens pass the test, the weld will be considered satisfactory. c) If two of three specimens fail, the welder will be considered to be an unqualified welder and shall be disqualified. <p>A disqualified welder may submit a new welding sample when he has had sufficient off-the-job training or experience to warrant re-examination.</p>

741.4 Field Joints: The Contractor shall obtain the services of qualified personnel to weld the liner plate field joints. Pipe joints must be dry before the liner plate joints are made. All mortar and other foreign material shall be removed from liner plate surfaces adjacent to the pipe joint, leaving them clean and dry.

No liner plate joints shall be made until the trench has been backfilled.

Field joints in the liner plate at pipe joints may be either of the following described types:

Type P-1- The joint shall be made with a separate 4 inch joint strip and 2 welding strips. The 4 inch strip shall be centered over the joint, secured to the liner plate with an approved adhesive, or other approved means, and welded along each edge to adjacent liner plate with a 1 inch weld strip. The width of the space between adjacent liner plate sheets shall not exceed 2 inches. The 4 inch joint strip shall lap over each liner plate a maximum of 1 inch.

Type P-2 - The joint shall be made with a plastic strip, without locking extensions integrally extruded with the liner plate and extending approximately 3 inches beyond the spigot end. A 1 inch welding strip is required. The joint strip shall overlay the liner plate a minimum of 1 inch on the downstream side of the pipe joint. An approved adhesive, or other approved means, shall be used to hold the lap in place during the welding. The joint strip on beveled pipe shall be trimmed to a width, measured from the end of the spigot, of approximately 3 inches for the entire circumferential length of the liner. Distortion in bending back the strip to expose the pipe joint during the laying and joint mortaring shall be avoided. All welding of joints is to be in strict conformance with liner plate manufacturer's specifications.

Type P-4 - The joint shall be made with a 4 inch weld strip. The 4 inch weld strip shall be centered over the joint and welded in place to the lining in adjacent joints of pipe. The weld strip shall lap over each liner plate in minimum of 1 inch.

Municipality	Supplements
PH:	<p>741.4 Installation of Liner Plate:</p> <p>The installation of liner plate, including the welding of all joints, shall be done in accordance with the manufacturer's recommendations. Liner plate shall be installed with locking extensions parallel with the longitudinal axis of the sewer, unless otherwise shown on the plans. All joints between individual sheets or sections of liner plates shall be continuously heat-welded by the use of welding strips of the same general composition and equivalent thickness of material as the liner plates (with the exception of the integral extension ribs).</p> <p>Liner plate shall be held snugly in place against inner forms by means of light gage steel wire, light steel banding straps or other suitable means. If steel banding straps are used, they shall be applied in strap channels provided for this purpose or onto flaps created at pipe ends.</p> <p>Locking extensions (T-shaped) shall be integrally extruded to all lower, terminal or longitudinal edges of liner plate as applied to concrete pipe. If banding straps are used, a steel rod ¼-inch in diameter may be inserted in each locking extension along the longitudinal edges of each sheet of liner plate for concrete pipe or some other approved method for holding the lower edge of the liner plate snugly against the form shall be provided. Concrete poured against liner plate shall be compacted in a careful manner so as to protect the liner plate and to produce a dense, homogeneous concrete securely anchoring the lock extensions into the concrete.</p> <p>In removing forms, care shall be taken to protect liner plate from damage. Sharp instruments shall not be used to pry forms from lined surfaces. All holes, cuts, torn or seriously abraded areas in the liner plate shall be patched. Patches made entirely with welding strip shall be fused to the liner plate over the entire patch. Larger patches may consist of smooth liner plate applied over the damaged area with adhesive. All edges must be covered with welding strip fused to the patch and the sound liner plate adjoining the damaged area.</p> <p>The Contractor shall take all necessary measures to prevent damage to installed liner plate from equipment and materials used in or taken through the work.</p> <p>The applied lining shall be free from bubbles due to poor workmanship, and the Contractor shall cut out said bubbles and weld a similar sheet in place of the bubble, unless otherwise directed by the Engineer.</p> <p>Application on Concrete Pipe-Special Requirements: Type P-1 joint, Liner plate shall be set to within ¼" of the inner edge of the bell or groove end of a pipe section and shall extend to within ¼" of the spigot or tongue end. Type P-2 joint, Liner plate shall be set to within ¼" of inner edge of the bell or groove end of a pipe section and shall extend a minimum of 3" beyond the spigot or tongue end.</p> <p>Wherever concrete pipe, which are protected with liner plate, join structures not so lined, such as brick structures, concrete pipe, cast-in-place structures or clay pipe, the liner plate shall be extended over and around the end of the pipe and back into the structure for not less than 2-inches.</p> <p>Where a pipe spur, not of plastic lined concrete, is installed through lined concrete pipe, the liner plate shall be returned not less than 2-inches at the surface of contact. The seal between the liner plate and the spur shall be made using an approved adhesive material and strapped in place. If the joint space is too wide or the joint space surface too rough to allow satisfactory sealing with this adhesive, the joint space shall be filled with 2-inches of densely caulked lead wool or other approved caulking material.</p> <p>Lined concrete may be cured by standard curing methods. Care shall be exercised, in handling, transporting and placing lined pipe to prevent damage to the liner plate. No interior hooks or slings shall be used in lifting pipe. All handling operations shall be done with an exterior sling or with a suitable forklift lifting the pipe only from the exterior.</p> <p>No pipe with damaged lining will be accepted until and unless the damage has been repaired to the satisfaction of the Engineer.</p>

741.5 Testing and Repairing Damaged Liner Surfaces: After the pipe is installed in the trench, all surfaces covered with liner plate shall be tested with an approved electrical holiday or flaw detector set at a minimum of 20,000 volts. All welds shall be physically tested by a non-destructive probing method. All patches over nail and form tie holes, or repairs to the liner plate wherever damage has occurred, shall be done in conformance with the instructions and recommendations of the liner plate manufacturer.

Each transverse welding strip which extends to a lower edge of the liner plate shall be tested. The welding strips shall extend below the liner plate, providing a tab. A 10-pound pull will be applied normal to the face of the pipe by means of a spring balance. Liner plate adjoining the welding strip will be held against the concrete during application of the force. The 10-pound pull will be maintained if a weld failure develops, until no further separation occurs. Defective welds will be re-tested after repairs have been made. Tabs shall be trimmed away neatly after the weld strip has passed inspection. The Contractor shall provide all equipment required to test liner plate in the manner recommended by the manufacturer and as described above. The Contractor shall also provide personnel qualified to perform the testing. Testing shall be performed in the presence of a representative of the Contracting Agency.

Municipality	Supplements
PH:	<p>41.5 Field Joints:</p> <p>The Contractor shall obtain the services of qualified and approved personnel to weld the liner plate field joints. Pipe joints must be dry before the liner plate joints are made. All mortar and other foreign material shall be removed from liner plate surfaces adjacent to the pipe joint, leaving them clean and dry.</p> <p>No field joint shall be made in liner until the lined pipe or structure has been backfilled and 7 days have elapsed after the flooding, jetting, or other means of compaction has been completed. Where groundwater is encountered, the joint shall not be made until pumping of groundwater has been discontinued for at least 7 days and no visible leakage is evident at the joint. The liner at the joints shall be free of all mortar and other foreign material and shall be clean and dry before joints are made. When the pipe liner coverage is 360 degrees, 6 to 8-inches of the downstream side of the joint strip or flap at the pipe invert shall not be welded.</p> <p>Heated joint compound shall not be brought in contact with liner.</p> <p>No coating of any kind shall be applied over any joint, corner, or welding strip, except where nonskid coating is applied to liner surfaces.</p> <p>Field joints in the liner plate at pipe joints may be either of the following described types:</p> <p>Type P-1 joint shall be made with a separate 4-inch joint strip and two (2) 1-inch welding strips. The 4-inch strip shall be centered over the joint, secured to the liner plate by heat sealing with hot air and welded along each edge to adjacent liner plate with a 1-inch weld strip. The width of the space between adjacent liner plate sheets shall not exceed 2-inches. The 4-inch joint strip shall lap over each liner plate a minimum of 1-inch.</p> <p>Type P-2 joint shall be made with an integral joint flap with locking extensions removed, extending a minimum of 3-inches beyond the spigot end of the pipe. The flap shall overlap the adjacent lined pipe and shall be heat sealed to this lining and then welded on the edge to the adjacent liner with 1-inch weld strip. Care shall be taken to protect the flap from damage. Excessive tension and distortion while bending the flap back to facilitate laying and joint mortaring shall be avoided. Heat shall be applied to straighten the PVC flaps as needed to prevent cracking of the PVC.</p> <p>Any flap which has been bent back and held shall be allowed to return to its original shape and flatness well in advance of making the liner joint.</p> <p>If joints are to be mortared, field joints on liner at pipe joints shall not be made until the mortar in the pipe joint has been allowed to cure for at least 48 hours and the pipe has successfully passed the leakage tests.</p>

Municipality	Supplements
PH:	<p>741.6 Installation of Welding Strip: Welding strips shall be fusion welded to joint strips and liner by welders approved by the Engineer, and trained by the manufacturer, using only approved methods and techniques.</p> <p>Adequate ventilation shall be maintained during all welding operations.</p> <p>Hot air welding tools shall provide clean effluent air at constant pressure to the surfaces to be joined within a temperature range between 260°C and 315°C (500°F and 600°F).</p> <p>For lap welds, the welding strip shall be positioned so that approximately 1/3 of the width is placed on the high side of the lap and properly fused. The weld strip shall be completely fused across its' entire width, except for a small allowable gap in the center. Incomplete fusion, charred, or blistered welds will be rejected by the Engineer.</p>

Municipality	Supplements
PH:	<p>741.7 Joint Reinforcement. A 12-inch long welding strip shall be applied as reinforcement across each transverse joint, weep channel, or return which extends to the lower terminal edge of liner. These reinforcement strips shall be centered over the joint being reinforced and located as close to the edge of liner as possible.</p>

Municipality	Supplements
PH:	<p>741.8 Testing and Repairing Damaged Liner Surfaces: After the pipe is installed in the trench, all surfaces covered with liner plate shall be tested with an approved electrical holiday detector set at a minimum of 20,000 volts. All welds shall be physically tested by a non-destructive probing method. All patches over repairs to the liner plate wherever damage has occurred shall be done in conformance with the instructions and recommendations of the liner plate manufacturer.</p> <p>The Contractor shall provide adequate ventilation, ladders for access, barricades or other traffic control devices, and shall be responsible for opening and closing entrances and exits. All areas of liner failing to meet the field test shall be properly repaired and retested. The electrical holiday detector shall be supplied by the Contractor and shall be a Tinker & Rasor Holiday Detector (Model AP-W).</p> <p>The Contractor, at his expense, shall have an independent inspection service perform the visual inspection and the probing of all weld joints. The independent inspection service and the inspection and probing procedures shall be approved by the Engineer. In addition, the independent inspection service shall witness the spark testing and any repairs performed by the Contractor. Inspectors employed by the independent inspection service to test the welds shall have passed the qualification welding test specified in Section 741.3. Upon completion of all liner testing and inspection, the Contractor shall submit certification by the independent inspection service that all installation and weld joints have been tested and inspected and are in compliance with the Specifications. However, this certification shall not relieve the Contractor of the responsibility to correct defective work.</p>

Municipality	Supplements
PH:	<p>741.9 Payment: Payment for plastic liner materials, their installation and testing shall be included in the price bid for the pipe or structure to which they are applied.</p>

VITRIFIED CLAY PIPE

743.1 GENERAL:

Vitrified clay pipe, 30 inch diameter or less, shall be extra strength in accordance with the requirements set forth in ASTM C-700, except as modified herein. Pipe larger than 30 inches shall be of the type specified in the Special Provisions.

743.2 MANUFACTURING REQUIREMENTS:

743.2.1 Shape: Pipe ends shall be square with the longitudinal axis, and sockets shall be true, circular, and concentric with the barrel of the pipe.

The ends of the pipe shall be so formed that when the pipes are laid together and the joints made, they shall constitute a continuous and uniform line of pipe and shall have a smooth and regular interior surface.

743.2.2 Stoppers, Branches, Ends: Stoppers shall be used with all branch pipes that are to be left unconnected. Stoppers for branch pipes having flexible compression joints may be either clay discs with flexible compression joints, factory applied, that will mate with the branch joint; or, a resilient material of controlled design and dimensions for mating with the branch pipe to which it is to be applied; or, of other material approved by the Engineer. Wooden stoppers will not be accepted.

Branches shall be furnished with connections of the sizes specified, securely and completely fastened to the barrel of the pipe in the process of manufacture.

“T” branches shall have their axis perpendicular to the longitudinal axis of the pipe. “Y” branches shall have their axis 45 degrees (unless otherwise specified) from the longitudinal axis of the pipe, measured from the socket end.

All branches shall terminate in sockets. Barrel of the branch shall be of sufficient length to permit making proper joint when the connecting pipe is inserted in the branch socket.

743.2.3 Imperfections: The following additional imperfections in a pipe or fittings will be considered injurious and cause for rejection:

- (A) Any surface fire crack in the ends of the spigot or bell which exceeds 1 inch in length.
- (B) Any piece broken from the bell end of the pipe or fittings when it adversely affects the performance of the joint or connection.

743.2.4 Certification: A certificate from the manufacturer shall be furnished attesting that the pipe meets the requirements of this specification, including test reports for the hydrostatic pressure test and the loading test herein specified.

743.3 TESTS:

In addition to the required tests at the manufacturer's plant, the Engineer's representative may select specimens at random at the point of delivery or at the job site. Tests on these specimens shall be performed at a local testing facility under the supervision of the Engineer's representative. The cost of such supervision will be borne by the Contracting Agency and all other costs shall be borne by the Contractor.

When the pipe is subjected to an internal hydrostatic pressure of 10 psi for the time shown in Table 743-1, the accumulated moisture on the exterior surface shall not run down the sides in such quantity that will exceed 10 milliliters.

TABLE 743-1	
TABLE OF TESTING TIME FOR PIPES	
Thickness of Wall Inches	Test Time Minutes
Up to and including 1	7
Over 1 and including 1 1/2	9
Over 1 1/2 and including 2	12
Over 2 and including 2 1/2	15
Over 2 1/2 and including 3	18
Over 3	21

The loading test shall conform in manner to that specified in ASTM C-301 for 3-edge bearing and shall be applied to all specimens selected for testing.

743.4 IDENTIFICATION MARKS:

Pipe and fittings shall be clearly marked with the name or trademark of the manufacturer, a code number identifying production control and plant location, and extra strength designation.

743.5 JOINTS:

Acceptable joints shall be flexible compression type for bell and spigot pipe or flexible compression couplings for plain-end pipe.

Compression joints and couplings shall conform to the requirements of ASTM C-425.

ABS TRUSS PIPE AND FITTINGS

744.1 GENERAL:

Truss pipe is defined as an internally-braced double-walled ABS composite pipe conforming to ASTM D-2680. When noted on the plans or in the special provisions, gravity sanitary sewer system may be constructed using truss pipe for diameters not exceeding 15 inches.

Truss pipe shall have both ends of each pipe length sealed at the factory such that the inert filler material between the two concentric thermoplastic tubes is impervious. All field cuts shall be sealed according to the manufacturer's recommendations.

744.2 COUPLINGS AND FITTINGS:

Fittings for truss pipe may include couplings, wyes, tees, elbows, caps, plugs adapters, manhole water stops and clamps. All couplings and fittings shall be assembled by a chemically welded method. Solvent shall be of the type recommended by the pipe manufacturer. Each solvent weld type coupling or fitting shall be accurately formed and entirely compatible in jointing the pipe to assure a leak-proof joint. Couplings and fittings shall be manufactured from the same material as the pipe except that caps, plugs and adapters may be fabricated or molded from rubber, polyurethane or other suitable compounds. The couplings and fittings shall have chemical and physical properties equal or superior to the pipe itself.

744.3 SOLID WALL PIPE AND FITTINGS:

744.3.1 General: When noted on the plans or in the special provisions, Sewer and Drain Solid Wall Pipe and Fittings may be used for 4 inch and 6 inch service lines, risers and fittings.

744.3.2 Material: Sewer and Drain Solid Wall Pipe shall be manufactured of virgin ABS compound as specified in ASTM D-1788, Types I and IV, excepting that the minimum heat deflection temperature (ASTM D-648) shall be 180°F.

744.3.3 Strength: Test samples of pipe, 6 inches long, shall be cut from full length sections and tested by the method outlined in ASTM D-2412. The pipe shall be deflected at least 35 percent without failure and the stiffness at 5 percent deflection shall equal or exceed the value listed in Table 744-1 below after the test samples have been immersed in a 5 percent solution by weight of sulfuric acid and n-Heptain for a period of 24 hours prior to testing. Failure is defined as rupture of the pipe wall.

Stiffness factor may be computed by the method outlined in ASTM D-2412 or by dividing the load in lbs/linear inch by the deflection in inches and 5 percent deflection ($F/_Y$ in Table 744-1).

TABLE 744-1	
MINIMUM STIFFNESS REQUIREMENTS	
Nominal Size	$F/_Y$ 2.5% min.
4 inches.....	55 lb./in. ²
6 inches.....	55 lb./in. ²

744.3.4 Couplings and Fittings: All couplings and fittings shall be assembled by a chemically welded method. Each solvent weld type coupling or fitting shall be accurately formed and entirely compactable with the Sewer and Drain Solid Wall Pipe to assure a leak proof joint. Couplings and Fittings shall be manufactured from the same material as the pipe except that caps, pugs and adapters may be fabricated or molded from rubber, polyurethane or other suitable compounds. The couplings and fittings shall have chemical and physical properties equal or superior to the pipe itself.

744.4 MANHOLE CONNECTIONS:

A clamp gasket or approved equivalent method shall be provided at manhole entry or connection to reduce infiltration and exfiltration. Where precast manholes are used, entrance holes must be large enough to allow for proper grouting around the manhole gasket.

744.5 CERTIFICATION:

A certificate from the manufacturer shall be furnished attesting that the pipe meets the requirements of ASTM D-2680.

744.6 IMPERFECTIONS:

Any imperfections which in the opinion of the Engineer may adversely affect the performance of the pipe or joints shall be cause for rejection.

744.7 INSTALLATION AND TESTING:

Truss pipe shall be installed in accordance with applicable provisions of Section 615. In addition to the tests prescribed in Section 615, the Engineer may, at his option, require a deflection test on all or any part of the line. Any pipe which shows deflection in excess of 5% shall be removed and replaced at no cost to the Contracting Agency.

PVC SEWER PIPE AND FITTINGS

745.1 GENERAL:

This specification covers the requirements of polyvinyl chloride (PVC) plastic sewer pipe and fittings for gravity flow sewers and building connections. When noted on the plans or in the special provisions, gravity sanitary sewers may be constructed using PVC pipe for diameters not exceeding 15 inches. Pipe, fittings, couplings and joints shall be in conformance with the requirements of ASTM D-3034, SDR-35, except as modified herein.

Municipality	Supplements
SC:	<p>745.1 GENERAL: <i>Delete this paragraph in its entirety and replace it with the following paragraph.</i></p> <p>This specification covers the requirements of polyvinyl chloride (PVC) plastic sewer and storm drain pipe and fittings for gravity flow sewers and building connections and gravity flow storm drains. PVC sewer pipe, fittings, couplings, and joints up to 12 inches in diameter shall be in conformance with the requirements of ASTM D-3034, SDR-35, 46 psi stiffness factor, except as modified herein. PVC sewer and storm drain pipe, fittings, couplings, and joints from 18 inches to 27 inches in diameter shall be in conformance with ASTM F-679, T-1 wall thickness, 46 psi stiffness factor.</p>

745.2 MATERIALS:

745.2.1 Caps and Plugs: Caps and plugs for building connections may be molded or fabricated from rubber, polyurethane or other suitable compound.

745.2.2 Gaskets: Rubber gaskets shall be manufactured from a synthetic elastomer and shall comply in all respects with the physical requirements specified in ASTM F-477.

745.2.3 Lubricant: The lubricant used for assembly shall have no detrimental effect on the gasket or on the pipe.

745.4 JOINING SYSTEMS:

Joints for the piping system and fittings shall consist of an integral bell gasketed joint designed so that when assembled, the elastomeric gasket located within the bell is compressed radially on the pipe or fitting spigot to form a positive seal. The joint shall be designed so to prevent displacement of the gasket from the joint during assembly and when in service.

All pipe shall have a home mark on the spigot end to indicate proper penetration when the joint is made.

The bell and spigot configurations for the fittings shall be compatible to those used for the pipe.

Joints shall provide a permanent seal against exfiltration and infiltration. All surfaces of the joint upon which the gasket may bear shall be smooth and free of any imperfections which could adversely affect sealability.

The assembly of the joints shall be in accordance with the pipe manufacturer's recommendations.

745.5 FITTINGS:

Fittings for PVC pipe may include elbows, wyes, tee wyes, double bell couplings, manhole couplings, manhole adapter rings, plugs, caps, adapters and increasers.

Manhole couplings shall be manufactured from asbestos cement and incorporate an elastomeric gasket moisture barrier.

745.5.1 Manhole Connections: A manhole adapter gasket or approved equivalent method shall be provided at manhole entry or connection to prevent infiltration and exfiltration. Where precast manholes are used, entrance holes shall be large enough to allow for proper grouting around the manhole ring.

745.6 CERTIFICATION:

A certificate from the manufacturer shall be furnished certifying that the pipe and fittings meet the requirements of ASTM D-3034, SDR-35, $F/Y \geq 2.5\%$ min. $Y = 46$ psi at 5% deflection.

745.7 IMPERFECTIONS:

Any imperfections which in the opinion of the Engineer may adversely affect the performance of the pipe or joints shall be cause for rejection.

IRON WATER PIPE AND FITTINGS

750.1 CAST IRON WATER PIPE:

All cast iron water pipe shall be designed in accordance with AWWA C-101.

Cast iron water pipe may be designed for either 18/40 or 21/45 physicals and shall conform to AWWA C-106 or AWWA C-108.

Except as otherwise provided cast iron or water pipe shall be designed to meet internal pressure of 150 psi, external cover of 5 feet, and standard Laying Condition B.

Cast iron pipe shall be nominal 18 foot lengths.

Pipe shall be cement mortar lined and seal coated in accordance with AWWA C-104.

Municipality	Supplements
PH:	<p>50.1 Lining For Ductile Iron Sewer Pipe And Fitting All ductile iron pipe for conveying sewerage shall be in accordance with AWWA C-150:</p> <ul style="list-style-type: none"> • 14" inside diameter and smaller shall be pressure class 350 • 16" inside diameter through 24" inside diameter shall be pressure class 250 • 30" inside diameter and larger shall be pressure class 150 <p>Ductile iron pipe with a minimum wall thickness of Class 50 may be substituted in lieu of the above.</p> <p>The lining shall cover, at a minimum, the inner surfaces of the pipe and the fitting from the plain end or beveled spigot end to the rear of the gasket socket. If flanged fittings and pipe are included in the project, the lining must not be used on the face of the flange, however full face gaskets must be used to protect the ends of the pipe. At the ends of the pipe and fittings, the lining thickness shall taper for a distance of four inches to a minimum thickness of ten mils.</p> <p>All ductile iron sewer pipe shall have a protective lining with a nominal thickness of 40 mils and a minimum thickness of 35 mils of Protecto 401 (ceramic epoxy), Polythane (polyurethane), throughout the barrel area of the pipe. However, the lining in the bell area shall transition to a minimum thickness of ten mils at the edge of the gasket socket. The ten-mil lining shall extend into the gasket socket area to a point where the gasket would overlap the lining when it is compressed due to pipe assembly during construction. The ten-mil lining shall also continue from inside the barrel area, around the spigot end of the pipe and along the outside of the pipe to a point where the center of the gasket of the next pipe section would contact the edge of the lining on the spigot end of the previous pipe section. The thickness of the linings shall be determined by using a dry film thickness magnetic gauge at four quadrants.</p> <p>Each section of pipe and each fitting shall be tested and shall have an absence of holidays when tested by a suitable holiday detector. In all cases, the barrel area of the pipe shall be tested using a voltage of 2, 500 volts and a dry conductive probe.</p> <p>Holiday testing shall conform to ASTM G 62-87 and NACE Standards RP0274-74 and RP0188-90 (latest revision).</p> <p>The pipe manufacturer shall be solely responsible for the quality of the lining and shall supply a certification as to compliance to the specification. The certification shall state specifically the following items:</p> <ol style="list-style-type: none"> 1. All ductile sewer pipe and fittings have a protective lining of 40 mils (35 mils min) in the barrel area, ten mils in the bell area and ten mils minimum on the exterior of the spigot end. 2. Each section of pipe and each fitting have been tested for holidays utilizing a test voltage of 2,500 volts with a dry conductive probe in the barrel area and a test voltage of 67.5 volts with a wet sponge in both the bell area and the exterior of the spigot end, and no holidays were found.

	<p>3. The lining material used meets the current specifications and that the material was applied as required by the specification.</p> <p>If the Contractor makes a field cut of the lined ductile pipe, the Contractor shall comply with the recommendations of the pipe manufacturer in applying a field coating to the end of the pipe ends. In all cases, as a minimum, a ten mil coating shall be applied to the pipe end and shall overlap the lining by four inches and extend around the pipe end and along the outside of the pipe a minimum of ten inches. The coating shall be allowed to dry before assembly. In addition, the overlapped surface of the lining shall be roughed up to produce a three to five mil profile over the entire surface. The end result of this process is to insure proper adhesion of the field coating.</p> <p><u>Repair</u> Repair of the damaged sections of the lining shall be in accordance with the lining manufacturer's recommendation or as specified above so that the repair area is equal to the undamaged lined area in all respects. All damaged lined areas and holidays shall be repaired immediately after discovery.</p> <p>Holiday testing may be required by the Engineer before pipe assembly when deemed appropriate. The testing and repair requirements shall follow the procedures called for in this specification and all cost for such repairs will be the responsibility of the Contractor.</p> <p>There will be no other provision for repair of the lining of DIP.</p> <p><u>Protective Collar</u> In order to protect the exterior spigot end against abrasion and damage during shipping and handling, the manufacturer shall install temporary collars on the exterior of each spigot end of each pipe section. The manufacture shall secure the collars to the pipe to prevent accidental removal during shipping and normal handling by the Contractor. The collars are not to be removed from the pipe until right before the pipe section is to be installed or field cut.</p>
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750.2 DUCTILE IRON WATER PIPE:

All ductile iron water pipe shall be designed in accordance with AWWA C-150 and shall be manufactured in accordance with AWWA C-151. The class shall be as designated in the plans or special provisions.

Pipe shall be cement mortar lined and seal coated in accordance with AWWA C-104.

Municipality	Supplements						
PH:	<p>50.2 DUCTILE IRON WATER PIPE: is modified to add:</p> <p>Ductile iron water pipe shall be of minimum pressure class as follows in accordance with AWWA C-150:</p> <table> <tr> <td>14" and smaller</td><td>350</td></tr> <tr> <td>16" through 24"</td><td>250</td></tr> <tr> <td>30" and larger</td><td>150</td></tr> </table> <p>All ductile iron water pipe shall be cement-mortar lined and seal coated in accordance with AWWA C-104.</p> <p>For ductile iron pipe eighteen (18) inches and larger, a manufacturer's pipeline layout shall be submitted showing the line layout with each fitting specified and detailed. Numbering of each standard joint is not required.</p> <p>The following are approved joint restraint methods for use with ductile iron pipe: flanged joint; Pacific States lock mechanical joint or restrained tyton joint; Ebba Iron, Inc. Series 1100 Megalug through 24"; Clow Super-lock joint; U.S. Pipe TR Flex gripper ring; U.S. Pipe TR Flex Joint; American Lok-ring joint; "American Flex-ring joint; Star Pipe Products Stargrip 4-inch; Griffin Pipe Snap-Lok; and Griffin Pipe Bolt-Lok; Romac Industries RomaGrip 3-inch through 12-inch; Romac Industries GripRing 4-inch through 12-inch; and Ford Meter Box Co. Uni-Flange Series 1400 4-inch through 12-inch."</p>	14" and smaller	350	16" through 24"	250	30" and larger	150
14" and smaller	350						
16" through 24"	250						
30" and larger	150						

Where tangential outlets are shown on plans, tangential outlets shall be furnished.

Weld-on boss outlets are not acceptable.

WELDED-ON OUTLETS FOR DUCTILE IRON PIPE LARGER THAN 16 INCHES

Scope:

Welded-on outlets shall be limited to branch outlets having a nominal diameter not greater than 70% of the nominal diameter of the main line pipe or 30-inch whichever is smaller (see Table No. 1). Welded-on outlets may be provided as a radial (tee) outlet, tangential outlet, or lateral outlet fabricated at a specific angle to the main line pipe, as indicated on the drawings. Welded-on outlets shall be fabricated by the pipe manufacturer at the same facility where the pipe is produced. The pipe manufacturer shall have a minimum of 5 years experience in the fabrication and testing of outlets of similar size and configuration.

Table No. 1: Main Line Nominal Diameter Versus Maximum Nominal Branch Outlet Diameter

Main Line Nominal Dia.	Branch Outlet Nominal Dia.	Main Line Nominal Dia.	Branch Outlet Nominal Dia.
18"	12"	42"	30"
20"	14"	48"	30"
24"	16"	54"	30"
30"	20"	60"	30"
36"	24"	64"	30"

Outlet Joint Types:

The joints on welded-on branch outlets shall meet, where applicable, the requirements of ANSI/AWWA C111/A21.11 and/or ANSI/AWWA C115/A21.15.

Design:

Weldment for welded-on outlets shall be based on the method described in Section VIII of the ASME Unfired Pressure Vessel Code. Reinforcing welds shall be placed using Ni-Rod FC 550 cored wire or Ni-Rod 550 electrodes manufactured by INCO Alloys (or an electrode with equivalent performance properties). Carbon Steel electrodes are not acceptable.

Parent pipe and branch outlet pipe shall be centrifugally cast ductile iron pipe designed in accordance with ANSI/AWWA C150/A21.50 and manufactured in accordance with ANSI/AWWA C151/A21.51. Minimum classes shall be: for sizes 4-inch through 54-inch, Special Thickness Class 53; for sizes 60-inch through 64-inch, Pressure Class 350.

Testing:

All welded-on outlets shall be rated for a working pressure of 250 psi and must have a minimum safety factor of 2.0 based on proof of design hydrostatic test results. The manufacturer shall, at the request of the owner or owner's Engineer, provide representative proof test data confirming hydrostatic test results and safety factors.

Prior to the application of any coating or lining in the outlet area all weldments for branch outlets to be supplied on this project shall be subjected to an air pressure test of at least 15 psi. Air leakage is not acceptable. Any leakage shall be detected by applying an appropriate soapy water solution to the entire exterior surface of the weldment and adjoining pipe edges or by immersing the entire area in a vessel of water and visually inspecting the weld surface for the presence of air bubbles. Any weldment that shows signs of visible leakage shall be repaired and retested in accordance with the manufacturer's written procedures.

Quality Assurance:

The manufacturer shall have a fully documented welding quality assurance system and maintain resident quality assurance records based on ANSI/AWS D11.2, the Guide for Welding Iron Castings. The manufacturer shall maintain appropriate welding procedure specification (WPS), procedure qualification (PQR), and welder performance qualification test (WPQR) records as well as appropriate air test logs documenting air leakage tests. The manufacturer shall have ISO 9001 or 9002 registration.

	<p>Prior to the start of manufacturing any proposed manufacturer not meeting ISO 9001 or 9002 registration requirements shall submit to the owner or owner's Engineer the name of an Independent Inspection Agency and the agency's qualifications. Submitted qualifications shall include but are not limited to the following:</p> <ul style="list-style-type: none"> • List of project references for projects of similar type and size • Resumes for inspection and testing personnel • Capacities for chemical and mechanical testing of material specimens • Frequencies for all instrument and testing equipment certifications <p>The independent inspection agency shall be responsible for all of the following:</p> <ul style="list-style-type: none"> • Verify compliance to written welding procedures specification (WPS) and procedure qualification (PQR) • Verify qualification of all welders (WPQR) per ANSI/AWS D11.2 criteria • Document use of Ni-Rod FC 550 cored wire or Ni-Rod 550 electrodes manufactured by INCO Alloys (or an electrode with equivalent performance properties) • Witness and document all air testing of outlet welds. <p>Field Welding: No field welding shall be allowed. Should a leak be detected at a welded-on outlet after installation, the piece shall be removed and returned to the pipe manufacturer's facility, where originally produced, for repair.</p>
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750.3 JOINT REQUIREMENTS:

Push-on joints for cast iron or ductile iron water pipe shall conform to AWWA C-111 and shall include synthetic rubber gaskets and lubricant.

Mechanical joints for cast iron or ductile iron water pipe shall conform to AWWA C-111 and shall include cast iron glands, synthetic rubber gaskets, and T-head bolts and nuts.

Flanged joints for cast iron or ductile iron water pipe shall be as detailed on the plans or as designated in the special provisions.

Restrained Joints:

When noted on plans or approved by the Engineer, joints for push-on or mechanical jointed ductile pipe may be modified to provide a fully restrained joint. These modifications to push-on and mechanical joints, including but not limited to segmented or special glands and split sleeves, shall conform to AWWA C-111. The Engineer shall review and/or approve each manufacturer's modifications to the joint. Upon request of the Engineer, the manufacturer of the modified joint shall provide test data showing compliance with AWWA C-111.

750.4 FITTINGS:

Iron fittings shall be either Gray-Iron or Ductile Iron conforming to AWWA C-110 or AWWA C-153 with a minimum pressure rating of 250 psi. Flanged ends shall conform to AWWA C-110. Push-on and mechanical joints ends shall conform to AWWA C-111.

Fittings shall be cement mortar lined and coal-tar coated in accordance with AWWA C-104.

Municipality	Supplements
PH:	<p>50.4 Fitting: Change the second paragraph to read:</p> <p>Fittings for water pipe shall be cement mortar lined and seal coated in accordance with AWWA C-104.</p>

ASBESTOS-CEMENT WATER PIPE AND FITTINGS

752.1 GENERAL:

These specifications cover asbestos-cement pressure pipe intended for use in supply lines and distribution systems that carry water under pressure.

752.2 CLASSES:

Asbestos-cement pipe shall be manufactured and tested in accordance with AWWA C-400, except as modified herein, for pipe intended for use in water service at maximum operating pressures of 100, 150, or 200 psi. Pipe shall be designated as Classes 100, 150, or 200 respectively, for the corresponding maximum operating pressures. Unless shown otherwise on the plans or specified in the special provisions the minimum acceptable shall be Class 150.

752.3 MANUFACTURE:

The joining ends of the pipe shall be of such design that they may be properly connected to cast iron fittings and valves which are manufactured within the continental United States that meet applicable AWWA specifications. Pipe in sizes less than 6 inches in diameter may be supplied in either 10 foot or 13 foot lengths, and pipe in sizes 6 inches or greater in diameter shall be supplied in 13 foot lengths, except for random and special short lengths in all sizes as permitted in AWWA C-400.

752.4 INSPECTING AND TESTING:

The uncombined calcium hydroxide in the pipe and couplings shall not exceed 1 percent when tested in accordance with AWWA C-400. Certification of all manufacturer's tests in accordance with AWWA C-400 shall be required. In addition, the Contracting Agency may require all inspection and testing to be performed at the manufacturer's plant or at an approved testing laboratory.

All pipe manufactured outside the United States of America will be subject to inspection and testing by the Contracting Agency at the plant site or at an approved testing laboratory. In addition, all pipe shall have the Underwriters Laboratory, Inc. seal of approval and certification that all tests were in accordance with AWWA C-400.

752.5 FITTINGS:

Fittings shall be cast iron or ductile iron and conform to AWWA C-110 or C-153 for 250 psi minimum working pressure rating cast on fittings. All fittings shall have Ring-Tite, Fluid-Tite, or Weld-Tite bells to fit the class of pipe specified. All fittings shall be cement lined in accordance with AWWA C-104.

752.6 RUBBER RINGS:

Each coupling shall have 2 synthetic rubber joint sealing rings conforming to the requirements of ASTM D-1869. This paragraph shall also apply to the rings furnished for use with fittings. Neoprene shall not be used.

GALVANIZED PIPE AND FITTINGS

753.1 GENERAL:

All galvanized pipe shall be new galvanized welded or seamless steel pipe, conforming to the requirements of ASTM A-53 standard weight, schedule 40.

753.2 CORROSION PROTECTION:

All buried galvanized pipe and fittings shall be protected from corrosion by the application of a tight fitting, extruded or wrapped coating. Coating shall be not less than 0.030 inches in thickness at any point. Extruded coatings shall be of polyethylene or polyvinyl chloride, Extrucoat or equal. Wrapped coatings shall be of polyethylene, polyvinyl chloride, coal tar or asphalt tape, Pretecto Wrap No. 200, Saft-t-Clad FOS No. 655, Tapecoat, Trantex VID-10 or E-12, Polyken No. 900, Scotchrap No. 50 or approved equal Tape shall be edge lapped no less than 1/4 inch.

753.3 FITTINGS:

All fittings for screwed galvanized pipes shall be 150 psi, banded, galvanized malleable iron screwed fittings.

753.4 VALVES:

Valves on galvanized pipelines shall be all bronze, double disc, nonrising stem with wheel handle on top, such as Jones, J373 or equal, with bodies, bonnets, yokes and wedges made of material conforming to ASTM B-62.

COPPER PIPE, TUBING AND FITTINGS

754.1 PIPE AND TUBING:

All copper pipe and tubing shall be new seamless copper pipes and tubes, designed for underground water services, plumbing purposes, etc. They shall conform to all the requirements of ASTM B-88, Type K.

All pipe or tubing shall be made of copper free from cuprous oxide, as determined by microscopic examination at a magnification of 75 diameters.

Type K tubing, when furnished in coil, shall be annealed after coiling.

754.2 FITTINGS:

All fittings used in connection with copper pipe or tubing, shall be copper or bronze fittings as manufactured by Jones, Mueller, or approved equal, as shown on standard details.

POLYETHYLENE PIPE FOR WATER DISTRIBUTION

755.1 GENERAL:

This specification is intended to describe water service pipe with a hydrostatic design stress of 620 psi for water at 73.4 °F. produced from a high density ultrahigh molecular weight polyethylene pipe compound. Polyethylene pipe used for water distribution shall conform to all the requirements of ASTM D-2239 and with the additional provisions listed herein. This specification describes pipe of the nominal I.D. and O.D. size as manufactured by Carlon, Celanese, Orangeburg, Phillips 66 Drisco pipe and Triangle Aycee and shall provide a water pressure tight joint when used with compression type fittings furnished by Hays, Haystite, Ford Meter Box, Ford Pack Joint, or approved equal.

Pipe may be rejected for failure to comply with any requirements of these specifications.

755.2 MATERIAL:

The polyethylene extrusion compound from which the pipe is extruded shall meet the requirements of Type III, Grade 34, Class C, material as described in ASTM D-1248, except that the melt index shall be determined under a higher temperature than ASTM D-1238. The test condition shall be as specified below under tests of pipe.

The pipe shall be homogeneous throughout and free of visible cracks, holes, foreign inclusions or other defects. The pipe shall be uniform in color, opacity, density, and other physical properties.

755.3 PIPE DIMENSION AND TOLERANCES:

The average inside diameters, wall thickness, and respective tolerances shall be, for any cross section, as shown in ASTM D-2239, when measured in accordance with ASTM D-2122.

The standard thermoplastic pipe dimension ratio (SDR), the ratio of the pipe diameter to wall thickness, shall not exceed 7 for 160 psi design pressure.

755.4 MINIMUM BURST PRESSURE:

The minimum burst pressure for pipe made from Type III, Grade 34, Class C, polyethylene compound, Designation Code: PE-3406, when determined with at least 5 specimens shall be at least equal to 630 psi for water at 73.4°F. Pressures shall be determined in accordance with ASTM D-1599.

755.5 SUSTAINED PRESSURE:

In addition to passing the sustained pressures given in ASTM D-2239 for a temperature of 100°F. and 73.4°F. the pipe shall withstand, without failing, ballooning, bursting or weeping for a period of at least 300 hours, at $194 \pm 2^\circ\text{F}$., 113 psi test pressure for 3/4 inch pipe and 112 psi for 1 inch pipe. These test pressures have been calculated on a basis of a 450 psi fiber stress. The test procedure outlined in ASTM D-1598, shall be followed.

755.6 TESTS OF PIPE:

The pipe must be able to meet all tests that are specified in ASTM D-2239, and the following test for melt index, as determined in ASTM D-1238. Pellets of the original resin, placed into the testing device shall have flow rates as follows:

(A) Less than 0.5 grams per 10 minutes at 310°C with a plunger load of 27.5 pounds for pipe or tubing extruded by the Allied Chemical Process.

(B) Less than 3 grams per 10 minutes at 190°C with a plunger load of 47.65 pounds for pipe and tubing extruded by the Phillips Extrusion Process.

755.7 CERTIFICATION BY MANUFACTURER:

Each Contractor must be able to furnish a certification from the manufacturer of the pipe that the polyethylene plastic pipe is of uniform quality and will fully comply with these specifications, and that the pipe is manufactured of virgin polyethylene, that no scrap material has been used, and that it is satisfactory for potable water, in accordance with the specifications of the National Sanitation Foundation Testing Laboratories, Inc.

The pipe manufacturer shall further supply a copy of certification from the manufacturer of the polyethylene extrusion compound used to make the pipe that the compound fully complies with these specifications.

The manufacturer must have adequate equipment and quality control facilities to be sure that each extrusion of pipe is uniform in texture, dimension and strength, and have so manufactured this class of pipe in sufficient quantities to be certain that it will meet all normal field conditions of usage.

755.8 PIPE IDENTIFICATION:

The pipe shall be permanently marked indicating size and pressure-temperature rating. The appropriate lettering shall occur on the pipe at least once in every 24 inches. The seal of approval or marking of the testing laboratory shall be included in the marking on all pipe that is intended for transporting potable water.

PE PIPE MARKINGS

REQUIRED MARKINGS, EXAMPLE

Size	—	Pressure	—	Temp Rating	—	Test Lab. Seal
3/4"		160 psi		PE 3406		NSF

OTHER MARKINGS(Not required by Spec. to be marked)
(However pipe must comply)

SDR-7 (Shall not exceed 7)

CS-255-63 (This is a commercial standard designation of the U.S. National Bureau of Standard. Any other number (CS—
 —) is wrong)

NOTE: 3/4 inch Pipe has I.D. 0.824 inch, O.D. 1.060 inch and 3.328 inch circumference.
3/4 inch Tubing is not acceptable and has I.D. 0.681 inch, O.D. 0.875 inch, 2.747 inch circumference and an SDR-9 if shown.

FIRE HYDRANTS

Municipality	Supplements
ME:	FF. Section 756 – In addition to the standard requirements of this Section, the following requirements shall also pertain: Internal bronze parts shall be low-zinc (not more than seven percent (7%) zinc). There shall be two (2) hose nozzles, 2 ½-inches in diameter with National Standard Threads; and one (1) steamer connection 4 ½-inches in diameter with National Standard Threads. The only fire hydrants acceptable for installation in the City of Mesa water system are the Mueller Modern Centurion, Waterous Pacer Model WB-67, Clow Model F2500, and the Clow Medallion.

Municipality	Supplements
TE:	SECTION 756 All hydrants shall be per City of Tempe Specification, supplemented as follows: <ol style="list-style-type: none"> 1. Clow F2500, Mueller Centurion, Waterous WB67 Pacer (Improved Model) 2. Hose Nozzles: Number 2, Size 2 1/2" 3. Pumper Nozzles: Number 1, Size 4" 4. Type of Thread: Special Tempe Thread 6 to 1" A sample shall be submitted to the Water Superintendent and the Fire Chief for acceptance. 5. Barrel extension length shall be 3' 6" unless otherwise stated.

756.1 GENERAL:

Fire Hydrants furnished by the Contractor shall comply with AWWA C-502, supplemented as follows:

756.2 DRAWINGS:

Detail drawings or blue prints showing all components, principal dimensions, construction details and materials used shall be submitted to the Contracting Agency for approval. The Contracting Agency reserves the right to consider the quality, appearance and past performance of fire hydrants when reviewing drawings for approval.

756.3 HYDRANTS:

Fire hydrants shall be dry barrel similar or equal to the Corey or Mueller Improved Type. The inside diameter of the barrel shall be a minimum of 7 inches and the diameter of the main valve seat opening shall be not less than 5 inches. The entire valve assembly shall be effectively sealed against moisture.

All interior ferrous surfaces of the shoe exposed to fluid flow shall be epoxy coated to a minimum dry thickness of 6 mils. Epoxy coatings shall be factory applied by an electrostatic or thermosetting process in accordance with the manufacturer's printed instructions. The epoxy materials used shall be 100% powder epoxy or liquid epoxy that conforms to the requirements of AWWA C-550, and to the prevailing requirements of the Food and Drug Administration and of the Environmental Protection Agency.

Style of inlet connections shall be bell or mechanical joint with accessories, gland, bolts, gaskets and having a 6 inch diameter inlet connection. Facing of the main valve against seats shall be synthetic rubber or balata. The top of the stem or bonnet shall be equipped with the O-ring seal. Hydrants shall be constructed so that extension sections in multiples of 6 inches, with rod and coupling, can be added to increase barrel length. The hose and streamer nozzle connections shall match the standard size and threads per inch of the Contracting Agency. Operating and outlet nozzle cap nuts shall be of solid pentagonal shape. The pentagon shall measure fifteen-sixteenths to thirty-one thirty-seconds inch on side, 1 1/2 inch from point to flat. All barrels above ground shall have a prime coat and painted with two coats of fire hydrant yellow paint. Hydrants shall be constructed so that the standpipe can be rotated to at least 8 different positions.

Municipality	Supplements
SC:	<p style="text-align: center;">SECTION 756 FIRE HYDRANTS</p> <p>756.3 HYDRANTS: <i>Delete the text in this subsection in its entirety and replace it with the following:</i></p> <p>All fire hydrants furnished to, or installed in, the City shall conform to the following specifications:</p> <ol style="list-style-type: none"> (1) Hydrants shall be designed, manufactured, installed and tested in compliance with the latest edition of AWWA. C-502 Standard for Dry-Barrel Fire Hydrants, as published by the American Water Works Association. (2) Hydrants shall be designed to operate at the maximum pressure of the line, and tested at the same p.s.i. as the main line. (3) Hydrants shall be of the break flange traffic model type with a replaceable breakable unit immediately above the ground line for minimizing repairs due to traffic damage. (4) Hydrants shall be of the compression type. Construction such that the main valve closes with the water pressure to assure no loss of water in the event of damage to the upper portion of the fire hydrant. (5) Main valve opening shall have a minimum of diameter of 5 1/4 inch to assure optimum flow. The inside diameter of the barrel shall be a minimum of 7 inches. Facing of the main valve against the seats shall be synthetic rubber or balata. (6) Hydrants shall be of the drop top design with 0-ring seals to insure that the operating threads will be protected from water entry. Dry top design to include factory lubricated operating mechanism which allows supplemental lubricant to be added in the field without removal of the top section. Standard lubricant shall be either oil or grease, suitable for a temperature range of 40 degrees to 150 degrees F. (7) All hydrants shall have a weather shield at the operating nut to protect the clearance area between the top casting and the operating nut. (8) The operating nut shall be one-piece bronze casting, both the operating nut and the nozzle cap nuts to be National Standard Pentagon in shape and measure 1 1/2 inch from point of flat at the base of the nut. Nozzle caps to be provided with rubber gaskets. (9) Hydrants shall have two 2 1/2 inch diameter hose nozzles with National Standard Fire Hose Coupling Screw Threads, and one 4 1/2 inch diameter pumper nozzle with National Standard Threads. Both the Pumper and Hose Nozzle shall be threaded and locked into place with "O" rings used as pressure seals. The use of caulked type nozzles is prohibited. (10) Hydrant nozzle section shall be capable of rotation through 360 degrees with respect to the standpipe to allow the positioning of the hose or pumper nozzles. (11) Hydrant shall have identification mark indicating direction of opening right to left (counter clockwise). (12) Hydrants shall have permanent markings identifying the manufacturer name, size of main valve opening, and year of manufacture. (13) Hydrants shall have an automatic drain that is operated by the main valve rod. Drain valve is to open as the main valve is closed and close as the main valve is opened. Drain valve systems shall be fully automatic. Port and seats of drain valve to be bronze.

	<p>(14) The outside of the hydrant top section shall be painted a minimum of one coat of primer and two finished coats of chrome yellow enamel.</p> <p>(15) The shoe of the hydrant shall be provided with a mechanical joint connection, 6 inch in size. All interior ferrous surfaces of the shoe exposed to continuous fluid flow (including the valve plate and cup nut) shall be epoxy coated to a minimum dry thickness of 6 mils. Epoxy coating shall be factory applied by an electrostatic or thermosetting process in accordance with the manufacturers printed instructions. The epoxy material used shall be 100 percent powder epoxy or liquid epoxy that conforms to the requirements of AWWA C550 and to the prevailing requirements of the Food and Drug Administration and of the Environmental Protection Agency.</p> <p>(16) The hydrant shall have bronze valve seat and shall be threaded into bronze drain ring or shoe bushing to prevent electrolysis between these components.</p> <p>(17) Hydrants shall be designed to permit the use of extension sections and allow all parts to be removable from ground level without requiring excavation of the hydrant.</p> <p>(18) The friction loss must be guaranteed by the manufacturer to satisfy the following table:</p> <p>(19) <i>Pour a PCC Collar around the fire hydrant barrel in accordance with AWWA Standard M 17 as shown in COS Standard 2366.</i></p>
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756.4 MANUFACTURER:

The manufacturer shall guarantee that the hydrant is so constructed that the valve stem will not be bent when hydrant is damaged or broken at or near the grade level. A safety breaking flange or thimble, shall be provided. The friction loss must be guaranteed, by the manufacturer, to satisfy Table 756-1.

TABLE 756-1			
MAXIMUM PERMISSIBLE LOSS OF HEAD FOR HYDRANTS			
Number of Outlet Nozzles	Nominal Diameter of Outlet	Total Flow From Outlet Nozzles GPM	Maximum Permissible Head Loss PSI
2	2 1/2 inches	500	2.0
1	4 inches	600	2.5

Municipality	Supplements												
SC:	<p>756.4 MANUFACTURER: <i>Modify table 756-1 as follows:</i></p> <p style="text-align: center;">TABLE 756-1 MAXIMUM PERMISSIBLE LOSS OF HEAD FOR HYDRANTS</p> <table><tr><th>No. of Outlet Nozzles</th><th>Nom. Diam. of Outlet</th><th>Total Flow From Outlet Nozzles GPM</th><th>Maximum Permissible Head Loss PSI</th></tr><tr><td>2</td><td>2 1/2"</td><td>500</td><td>2.0</td></tr><tr><td>1</td><td>4 1/2"</td><td>600</td><td>2.5</td></tr></table>	No. of Outlet Nozzles	Nom. Diam. of Outlet	Total Flow From Outlet Nozzles GPM	Maximum Permissible Head Loss PSI	2	2 1/2"	500	2.0	1	4 1/2"	600	2.5
No. of Outlet Nozzles	Nom. Diam. of Outlet	Total Flow From Outlet Nozzles GPM	Maximum Permissible Head Loss PSI										
2	2 1/2"	500	2.0										
1	4 1/2"	600	2.5										

Municipality	Supplements
SC:	<p>756.5 CERTIFICATION</p> <p><i>The Contractor shall provide, to the City, manufacturer certifications attesting the fire hydrants as shown on the submitted product data sheets meet the requirements of this specification.</i></p>

SPRINKLER IRRIGATION SYSTEM

757.1 GENERAL:

All materials and fittings shall be new, of the manufacturer's most current design, and shall bear the appropriate National Association seal of approval for example, NSF, UL, etc. Similar units shall be procured from the same manufacturer and internal parts shall be common and interchangeable. Parts listing and source of supply for replacement parts will be furnished to the Engineer.

Municipality	Supplements
PH:	<p>757.1 GENERAL: Add the following paragraph:</p> <p>The Manufacturer of component equipment shown on the drawings or specified in the Special Provisions form the basis of the irrigation design as well as the physical and operational standards for which the components were selected. Component equipment from other manufacturers may be submitted, by the Contractor, to the Engineer for approval. No equipment however is to be ordered without approved shop drawings.</p>

757.2 PIPE AND FITTINGS:

The type of pipe material and fittings shall be as designated on the plans or in the special provisions. The type utilized shall comply with one of the following:

757.2.1 Steel Pipe: All steel pipe shall be newly galvanized, standard weight, Schedule 40 conforming with Section 753.

757.2.2 Plastic Pipe: Plastic pipe shall be rigid, unplasticized polyvinyl chloride, PVC 1120 or 1220, with an SDR of 26 or less, complying with ASTM D-1785. Schedule 40 or 315 psi pipe shall be used for the continuously pressurized run on the supply side of Control Valves. PVC 1120 to 1220, SDR 26, pressure rated at not less than 125 psi shall be used on the discharge side of all control valves.

Municipality	Supplements
PH:	<p>757.2.2 Plastic Pipe: Change this subsection to read:</p> <p>(A) Rigid Plastic Pipe shall be extruded from 100% virgin normal impact unplasticized polyvinyl chloride (PVC) Type I, Grade I or II resin 2000 psi (PVC 1120 or PVC 1220), design stress ASTM D1784, Department of Commerce PS-21-70, PS-22-70. Standard Dimension Ratio (SDR) 26 or less than 160 psi. Pipe shall conform to ASTM D-2241 and D-2672.</p> <p>Testing of pipe: Provide written certificate by supplier that polyvinyl chloride pipe has successfully passed the following tests:</p> <p>Acetone test: Immerse a sample of pipe in 99% pure anhydrous acetone for 15 minutes; at the end of this time there should be no evidence of flaking or delamination on the inner or outer walls of pipe. Evidence of softening or swelling shall not constitute failure.</p> <p>Flattening: Cut a specimen two inches long from each end of the pipe sample. Flatten each test specimen from parallel plates of a press until the distance between the plates, in inches, is equal to sixty (60) percent of the pipe O.D., and there shall be no evidence of cracking, splitting or breaking.</p> <p>The pipe shall be homogeneous throughout, free from visible cracks, holes, or foreign materials. The pipe shall be free from blisters, dents, wrinkles or ripples, die and head marks.</p> <p>Piping up to and including 2-1/2" size shall be SDR solvent welded.</p> <p>Pressure mainline piping 3" size and larger shall be gasket pocket type, as manufactured by the Swanson Co. or approved equal, and shall conform to ASTM F-477.</p>

	<p>Continuously and permanently mark pipe with manufacturer's name or trademark, kind and size (IPS) of pipe, material, manufacturer's lot number, schedule or type and NSF seal of approval.</p> <p>(B) Plastic Pipe Fittings and Couplings: For pipe fittings up to and including 2-1/2" size, fittings and couplings shall be either threaded type or slip fitting tapered socket solvent weld type. Schedule 80 pipe will only be used for threaded joints. Tapered socket solvent weld fittings may be either Schedule 80 or Schedule 40, but in either case, will be equal to or greater than the schedule and Pressure Rating of the plastic pipe being joined. Tapered fittings shall be sized so that a dry, unsoftened taper cannot be inserted more than halfway into the socket. Plastic saddles and flange fittings are not permitted.</p> <p>PVC fittings shall be marked with manufacturers name or trademark, type PVC, size and NSF seal of approval. Extruded couplings to be produced from NSF rated raw materials and meet ASTM standards.</p> <p>For pipe 3" and greater, fittings shall be ductile iron, grade 80-55-06, in accordance with ASTM A-536. Fittings shall have mechanical joints with gaskets meeting ASTM F-477. Fittings shall have radii of curvature conforming to AWWA C110.</p>
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757.2.3 Pipe Fittings and Couplings:

(A) Steel Pipe Fitting and Couplings - Steel pipe fittings and couplings shall be galvanized, malleable iron, screwed fittings or couplings, conforming with Section 753.

(B) Plastic Pipe Fittings and Couplings - Plastic pipe fittings and couplings shall be either threaded type or slip fitting tapered socket solvent weld type. Schedule 80 pipe only will be used for threaded joints. Tapered solvent weld fittings may be either Schedule 80 or Schedule 40, but in any case, will be equal to or greater than the Schedule and Pressure Rating of the plastic pipe being joined. Tapered fittings shall be sized so that a dry, unsoftened taper cannot be inserted more than halfway into the socket. Plastic saddles and flange fittings are not permitted.

(C) Copper Pipe Fittings and Couplings - Copper pipe fittings and couplings shall conform with Section 754.

757.2.4 Solvent Cement: The solvent cement shall be a solution of Type 1, Grade 1, unplasticized, polyvinyl chloride molding or extrusion compound as specified in ASTM D-1784, or an equivalent PVC resin. The cement shall be free flowing and shall not contain lumps, microscopic undissolved particles or any foreign matter that will adversely affect the ultimate joint strength. It shall show no stratification or separation that cannot be removed by stirring. Container labeling shall be in accordance with ASTM D-2564.

Municipality	Supplements
PH:	<p>757.2.5 PVC Primer</p> <p>The primer shall be specifically formulated for the pipe and type of connection, as recommended by the pipe manufacturer.</p>

757.3 VALVES AND VALVE BOXES:

757.3.1 General: Valves shall be of the size, type, and capacity designated on the plans or in the special provisions and shall comply with the requirements specified herein.

All valves except garden valves shall be capable of satisfactory performance at a working pressure of 200 psi. Valves shall be designed to permit disassembly to replace sealing components without removal of the valve body from the pipeline.

757.3.2 Gate Valves: Gate valves in size two inches and smaller shall be all bronze double disc wedge type with integral taper seats and non-rising stem. Sizes two and one-half inches and larger shall be iron body, brass trimmed, with the other features the same as for the two inch. Section 753 applies.

757.3.3 Manual Control Valves: Manual control valves shall be brass or bronze, and shall be straight or angle pattern glove valves, full opening, key operated with replaceable compression disc and ground joint union on the discharge end.

757.3.4 Electrical Remote Control Valves: Remote control valves shall be electrically operated, designed for a 24 volt, 60 cycle system. They shall be brass or bronze with accurately machined valve seat surfaces, equipped for flow control adjustment, and with the capability for manual operation. They shall be readily disassembled for repair and the internal parts shall be easily accessible for service even when installed in the line.

The internal valve shall be a normally closed, diaphragm type with slow opening and closing action as protection against surge pressures. Actuation shall be by an encapsulated type solenoid with the solenoid shunt band, tube, and plunger of stainless steel for corrosion protection. A removable and cleanable strainer shall be provided at the control chamber inlet to prevent debris from entering the solenoid operating section.

Municipality	Supplements
PH:	757.3.4 Electrical Remote Control Valves: change this section to read: The electric remote control valve listed on the plans or specifications and described by the manufacturer's most recent literature (catalogue cut sheet), constitute the quality and performance standards for the specified valve.

757.3.5 Garden Valves: Garden valves shall be brass or bronze except for the handle. They shall have a replaceable compression disc, and shall be 3/4 inch straight-nosed, key operated and pressure rated for operation at 150 psi.

757.3.6 Quick-Coupling Valves and Assemblies: Quick-coupling valves shall be brass or bronze with built-in flow control and self-closing valve and supplied in 3/4-inch size unless otherwise required. When a quick-coupler assembly is specified, it shall consist of the valve, quick-coupler connection and hose swivel. Keys and hose swivel ells shall be furnished as specified on the plans.

757.3.7 Valve Boxes: Valve boxes with locking covers shall be molded, non-corrosive plastic. Applicable ASTM references: D-638.

Municipality	Supplements
PH:	57.3.7 Valve Boxes: change this section to read: All valve boxes shall have stainless steel bolts and washers with lock down covers. Valve boxes and covers shall be molded, non-corrosive plastic, ASTM D638, D-356, except when located in paved surfaces. These shall be concrete boxes with lock down steel or concrete cover rated for traffic conditions to which it will be exposed.

757.4 BACKFLOW PREVENTER ASSEMBLY:

The backflow preventer assembly shall consist of pressure type or reduced pressure type backflow preventer unit and associated components conforming to the governing code requirements and as shown on the plans. It shall be equal in quality and performance to a "Foundation for Cross-Connection Control and Hydraulic Research."

Municipality	Supplements
PH:	757.4 Backflow Preventer Assembly: change this section to read: The Backflow Preventer Assembly shall consist of Pressure type, or Reduced Pressure type backflow preventer unit and associated components conforming to the governing code requirements and as shown on the plans or specifications. The backflow preventer unit shall be equal in quality and performance to the unit listed in the Contract Documents.

Municipality	Supplements
PH:	757.4.1 Backflow Preventer Cage: Pre-manufactured units shall be approved for use by the Engineer. The Contractor shall submit catalog information. Pipe used to support the units shall be not less than 1-1/4" schedule 40 and shall be ASTM A-53 Grade A electric weld Pipe, expanded metal shall be 1/2" spacing, #13 gauge flattened diamond pattern steel. There shall be no exposed ends of expanded metal on the outside of the enclosure. The expanded

	metal shall be “die formed” for uniformity. Welds shall be a minimum of ¼” long weld on a 4” spacing. All units shall withstand a minimum of 200 lbs. per square foot for 24 hours without deflection or distortion. Cage locking mechanism shall be vandal resistant. Cage shall be powder coated by electrostatic application to 1.5 to 2 mil thickness. Color shall be approved by the Engineer.
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757.5 SPRINKLER EQUIPMENT:

Sprinkler heads, bubbler heads and spray nozzles shall be of the types and sizes as shown on the plans. All major components shall be brass, bronze, stainless steel, or high impact plastic.

Equipment of one type with similar flow characteristics shall be from the same manufacturer and shall bear the manufacturer's name and identification code in a position where they can be identified after installation.

Fixed head sprinklers shall have a one-piece housing with provisions for interior parts replacement. Pop-up sprinklers shall be designed to rise at least 2 inches during operation. Full or part circle sprinklers shall be interchangeable in the same housing.

Bubbler heads shall be of corrosion-resistant, durable bodies, injection molded out of cycloc, and tapped for 1/2 inch I.P.S. threads. The bubbler shall be fully adjustable from 0 to 5 gallons per minute and shall have a minimum discharge of 1.7 gallons per minute under pressure of 15 pounds per square inch and a minimum discharge of 2.4 gallons per minute under pressure of 30 pounds per square inch supplied at the head.

Municipality	Supplements
PH:	757.5 Sprinkler Equipment: delete the last two paragraphs and substitute the following: Spray heads, impact sprinkler heads, rotor pop-up sprinkler heads, bubblers, emitters, etc., as shown on the plans or specifications and as described in the Manufacturer's latest literature (Catalogue cut sheets) constitute the performance and quality standards for this equipment.

757.6 ELECTRICAL MATERIAL:

All equipment and material shall comply with the requirements of the governing code and shall be listed by Underwriters' Laboratories, Inc.

757.6.1 Conduit: Conduit shall be galvanized steel conforming to Section 753.

757.6.2 Conductors: Service line conductors shall be supplied in the size shown on the plans and shall be THW 600 volts insulation rating conforming to ASTM D-2219 or D-2220. Low voltage control conductors shall be Type UF No. 14 AWG copper unless otherwise shown on the plan and shall be UL approved for direct burial installation.

757.6.3 Controller Unit: The controller unit shall be fully automatic, with provisions for manual operation, sized to accommodate the number of stations or control valves included in the system and designated on the plans or in the special provisions. Outdoor models shall be housed in a vandal-resistant, weatherproof enclosure which has a locking cover.

The unit shall require a standard 117 volt, 60 cycle input and provide a 26.5 volt, 60 cycle output and shall incorporate a 14-day programming capacity. The unit shall have a “Master On-Off” switch which will deactivate the controller but allow the day and hour clocks to continue operation.

In addition, it shall include a resettable circuit breaker for unit protection.

Each station timing dial shall have an “Omit” or “Off” position and incremental dial settings for timing controls up to 30 minutes.

Municipality	Supplements
PH:	757.6.4 Controller Unit and Assembly: delete this subsection and substitute the following: Controller Unit and Assembly: The Controller unit and assembly listed on the plans or specifications and as described in the Manufacturer's latest literature (Catalogue cut sheets) constitute the quality, performance and operational standards for the specified Controller.

CONCRETE PRESSURE PIPE - STEEL CYLINDER TYPE

758.1 GENERAL:

These specifications apply to Concrete Pressure Pipe intended for use in water supply pipelines that carry water under pressure. Concrete pressure pipe is specified as follows:

(A) Reinforced concrete pressure pipe-steel cylinder type, pretensioned, shall be designed, manufactured and tested in accordance with AWWA C-303. With agreement by the purchaser and the manufacturer, pipe may be manufactured to larger sizes and for higher pressures than indicated herein.

Reinforced concrete pressure pipe may be furnished in pipe diameters of eighteen (18) inches through seventy-two (72) inches.

Pipe shall be designed by the methods described in Appendix A, AWWA C-303 to resist the internal pressures and external loading conditions designated on the approved plans or in the project specifications.

(B) Prestressed concrete pressure pipe steel cylinder type, shall be designed, manufactured and tested in accordance with AWWA C-301 and AWWA C-304.

Prestressed concrete pressure pipe may be furnished in pipe diameters forty-two (42) inches and larger.

Pipe shall be designed by the methods described in AWWA C-304 to resist the internal pressures and external loading conditions designated on the approved plans or in the project specifications.

Municipality	Supplements
PH:	<p>758.1 GENERAL: is modified to add:</p> <p>All pipe shall be designed for 150 psi working pressure plus 60 psi surge pressure. Test pressure shall be 188 psi.</p> <p>The pipe shall be designed to support the earth cover over the pipe as shown by the pipeline profiles on the plans. Where the earth cover over the pipe is less than eight (8) feet, the design shall be based on eight (8) feet minimum cover. When the plans show both existing and future surface profiles, the critical cover shall be used for design purposes.</p> <p>Earth loads on pipe shall be calculated assuming the pipe is installed in a positive projecting embankment condition. The loading for positive projecting embankment condition shall be derived using a product of the projection ratio and the settlement ratio of 0.5. The Ku factor shall be 0.150. The soil unit weight shall be 140 pounds per cubic foot.</p> <p>Pipe reinforced with ring stiffeners will not be permitted. Dimensions of fittings and specials shall conform to AWWA C-208.</p> <p>Field joints for specials and fitting shall be as called for on the plans. Flanges shall be Class D steel ring flanges in accordance with AWWA C-207.</p> <p>758.1 (A) change second paragraph to read:</p> <p>Reinforced concrete pressure pipe may be furnished in pipe diameters of eighteen (18) inches through forty-two (42) inches.</p> <p>758.1 (A) Change the third paragraph to read:</p> <p>Pipe and fittings shall be designed by the methods described in AWWA Manual M9 to resist the internal pressures and external loading conditions designated on the approved plans or in the project specifications.</p>

	<p>758.1 (A) is modified to add:</p> <p>The pipe shall be designed for the maximum stress to be encountered in place as indicated on the plans, whether it be internal pressure, external backfill load, H-20 truck load on the backfill, or any combination of loading.</p> <p>The pipe shall be designed to limit the deflection of the pipe, in inches, under the external loads specified to not more than the square of the diameter of the pipe in inches divided by 4,000. Deflection shall be calculated by "Spangler's" formula using a bedding constant (K) of 0.1 and a module of soil reaction (E') of 1,000.</p> <p>The pipe shall be designed for external loading based on an H-20 truck loading and impact factors recommended by AASHTO for highway truck loads in "Standard Specifications for Highway Bridges."</p> <p>Immediately after the cement-mortar coating has been placed, the ends of each section of pipe shall be tightly capped with waterproof covers to prevent the escape of moisture when water curing. When steam curing, waterproof covers may not be necessary until completion of cure, provided prompt application of steam is begun. The waterproof covers shall become a component part of the completed pipe section, to protect the interior of the pipes, and shall remain on the pipe until it is installed in the trench.</p> <p>The minimum steel plate thickness for fittings and special pipe shall be 0.25 inches.</p> <p>For fittings and special pipe, the minimum cement mortar or concrete lining thickness shall be 0.75 inches and the 0.75 inches shall be the maximum thickness allowed for resisting any external loads and shall be so used and shown in any design calculations. External or outside cement mortar coating shall be limited to a maximum of 1.25 inches for the purpose of resisting any external loads.</p> <p>For standard pipe, the maximum allowable cement mortar coating shall be 1.25 inches, measured from the steel cylinder.</p> <p>758.1 (B) Change the end of the first paragraph to read: "and AWWA C-304"</p> <p>758.1 (B) Change the third paragraph to read: Pipe shall be designed by the methods described in AWWA C-304 to resist the internal pressures, and external loading conditions designated on the approved plans or in the project specifications.</p> <p>758.1 (B) is modified to add: Pipe may be either lined cylinder type or embedded cylinder type. Stress analysis of pipe shall be made using "Olander's" coefficients for a 120 degree bedding angle.</p> <p>Except as otherwise provided in this Section, fabricated steel plate fittings and specials shall be designed for internal pressure only. The internal pressure design shall be based upon a design stress of 15,000 psi. The minimum steel plate thickness shall be 1/4 inch.</p> <p>(1) Outlets, where specified on the plans, with an internal diameter of less than one-half the diameter of the mainline pipe shall be installed on prestressed concrete cylinder pipe. Outlets with an internal diameter greater than one-half the diameter of the mainline pipe or thirty-six (36) inches shall be designed and manufactured as a separate fabricated steel plate fitting.</p> <p>(2) The exterior of fabricated steel plate fittings and specials shall not be mortar coated, but shall be shop painted as provided in this section.</p> <p>(3) All fabricated steel plate fittings and specials shall be encased in reinforced concrete as shown on the details in the plans.</p> <p>At mainline valves, where a steel plate section is required to comply with plans and/or attach a companion flange for connection to the valve, the following shall apply to such plate sections:</p>
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	<p>(1) Design shall limit deflection to the square of the diameter in inches divided by 4,000 for pipe diameters less than sixty (60) inches. For pipe diameter sixty (60) inches and greater, deflection is limited to one and one-half (1-1/2) percent of the diameter.</p> <p>(2) Unless otherwise specified, plate sections shall not be longer than one (1) foot.</p> <p>(3) Plate sections shall comply with all other applicable provisions, MAG Specifications, Phoenix supplement to MAG and AWWA Standards and AWWA Manual of Water Supply Practices-M9, second edition, with the following exception. For design, the minimum cement mortar or concrete lining thickness shall be 0.75 inches and the 0.75 inches shall be the maximum thickness allowed for resisting any external loads and shall be so used and shown in any design calculations. External or outside cement mortar coating shall not be considered for the purposes of resisting any external loads.</p>
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758.2 MANUFACTURE:

The Contractor shall submit design calculations, a tabulated layout schedule, and details of specials and fittings to the Engineer for review and approval.

When specified in the project specifications, the manufacturer shall furnish all samples, test reports, test specimens and perform tests as provided in AWWA C-303 or AWWA C-301.

An approved rust inhibitor shall be applied on the exposed portions of the steel joint rings.

The Contractor shall submit an affidavit of compliance from the manufacturer that the pipe and fittings furnished comply with all applicable provisions of AWWA C-301 or AWWA C-303.

The Engineer or his representative shall be allowed access to the manufacturer's plant for the purpose of inspecting the pipe and fittings.

Municipality	Supplements
PH:	<p>758.2 Manufacture: is modified to read:</p> <p>An affidavit of compliance as specified in Section 1.11 of AWWA C-301 and Section 1.11 of C-303 shall be furnished to the Engineer.</p> <p>Cement used in manufacture of pipe shall conform to ASTM C-150, Type II, low alkali.</p> <p>No concrete admixture shall be used except as approved in writing by the Engineer.</p> <p>Liquid membrane-forming compounds shall conform to ASTM C-309, Type I, and shall be of such composition that after drying they will not impart taste or odor to water flowing through the pipe, nor will they contain any toxic materials. The use of such compounds shall be subject to the approval of the Engineer.</p> <p>Rust inhibitors used for preventing rust on steel surfaces at holdbacks of mortar lining and/or coating shall be quick-drying material with good bonding properties to the steel, and shall be tack-free and smooth within four (4) hours after applying.</p> <p>All joints shall be the Carnegie Bell and Spigot type with rubber gaskets. The joint rings for spigot ends for rubber gasket joints shall be Carnegie Shape M-3516, M-3818 or M-3836.</p> <p>Openings, connections and outlets shall be cement mortar lined and concrete coated as detailed on the plans.</p>

Municipality	Supplements
PH:	<p>758.3 Material Drawings: New Subsection:</p> <p>The Contractor shall furnish the Engineer with six (6) copies of shop drawings, pipe layout diagrams, manufacturer's catalog data, and detailed information, in sufficient detail to show complete compliance with all specified requirements, covering but not limited to the following items:</p> <p>Fabricated pipe and specials; design calculations; field closures; reinforcing steel and concrete mix designs.</p> <p>The manufacturer's complete design calculations shall be submitted to the Engineer for review prior to or with the Joint Detail submittal.</p> <p>The procedure outlined in American Water Works Association Manual M-9 will be used in determining the length of pipe requiring welded joints. Joint restraints design shall be based on test pressures. Shop drawing submittal shall include calculations showing the length of welded joints, tensile stress to be resisted by, and design of joint welds and pipe longitudinal reinforcement. Minimum design parameters shall be as follows: Soil unit weight is 110 pounds per cubic foot; soil friction coefficient 0.3; height of backfill over pipe - maximum four (4) feet or as shown on plans (if less than four (4) feet). Throat thickness of welds shall be based on an allowable stress of 8,800 pounds per inch per inch of throat thickness using an E60 low-hydrogen electrode. The allowable stress in the steel cylinder shall not exceed 15,000 psi.</p> <p>Shop Drawings and Line Layout:</p> <p>(A) The manufacturer's pipeline layout shall be furnished together with standard details for review. The line layout shall show each standard pipe joint and each special joint or fitting by number. Manufacturer's standard details shall be furnished in sufficient details to assure that the detail design of the pipe and specials will comply with the design concept and structural requirements of the project as presented in the Contract Documents. Full details of reinforcement, concrete, cement, mortar, joint dimensions, etc., for the straight pipe, specials and connections shall be furnished. Layout drawings shall show stations and the invert elevations of the pipeline.</p> <p>(B) Manufacturer's shop drawings shall be furnished for fabrication, inspection and record purposes in accordance with the "General Conditions". The manufactured pipe and specials shall conform to the approved standard details and shall meet all specified requirements unless otherwise approved in writing.</p> <p>(C) Valves and fittings to be incorporated in the pipeline shall be considered when preparing the pipeline layout.</p>

Municipality	Supplements
PH:	<p>758.4 Shop Inspection and Tests: New Subsection:</p> <p>(A) Inspection:</p> <ol style="list-style-type: none"> <li>(1) The City and its representatives shall have access to the work wherever it is in preparation or progress, and the Contractor shall provide proper facilities for access and for inspection during the manufacturing process. <li>(2) Inspection by the City or its representatives, or failure of the City or its representatives to provide inspection, shall not relieve the Contractor of his responsibility to furnish materials and to perform work in accordance with this specification. <li>(3) Material, fabricated parts, and pipe which are discovered to be defective or which do not conform to the requirements of this specification, will be subject to rejection at any time prior to final acceptance. Rejected material and pipe shall promptly be removed from the site of the work.

	<p>(B) Test and Materials:</p> <ol style="list-style-type: none"> (1) In advance of manufacture of the pipe, the Contractor shall furnish to the Engineer three (3) copies of the mill test certificate for all steel products incorporated in the pipe. Three (3) copies shall be furnished of mill test reports on each heat from which the steel is rolled. (2) Methods of Tests for Cement, Mortars and Concrete: <ol style="list-style-type: none"> (a) Mortar Lining: The mortar for all mortar lined pipe shall be sampled and molded by the following procedure: <p>The mortar sample shall be taken directly from the transfer bucket between the mixer and the charging trough which injects the mixed mortar into the spinning pipe. A sufficient amount shall be extracted to make four (4) 6" x 12" cylinders, and shall be placed in a wheelbarrow or other suitable container. The mortar sample material shall then be transported to the location at which the cylinder cans are to remain without moving for the next 24 hours. The mortar shall be thoroughly mixed immediately prior to pouring into the cylinders in order to prevent segregation. After the mortar has been thoroughly mixed, it shall be poured in a continuous stream into the cylinder cans. The cans shall immediately be capped and allowed to remain without disturbing for twenty-four (24) hours.</p> (b) Mortar Coating: Mortar for all mortar coated pipe shall be sampled by molding four (4) cylinders for compressive tests of the representative material being used to seat the pipe. The mortar sample shall be molded in 6" diameter cylinders in accordance with applicable provisions of ASTM D-558. (c) Curing of Test Cylinders: The curing of concrete, lining and coating cylinders for the first twenty-four (24) hours shall be the same as that for the pipe, except that the mortar for coating cylinders shall be covered with a piece of damp burlap to retard the drying out or the low moisture content of the mortar coating. At the end of twenty-four (24) hours, the cylinders shall be transported to a moist curing cabinet and cured in accordance with ASTM C-192. <p>Strength of Cement Mortar Lining, Coating, Concrete and Steel:</p> <ol style="list-style-type: none"> (a) <u>Mortar Lining</u>: The average compressive strength, as per Section C below, of cylinders for mortar lining for the several types of pipe shall be as follows: <ol style="list-style-type: none"> (1) <u>Semi-Rigid Pipe</u> <p>Steel pipe and steel cylinder pipe, single wrap, pretensioned, the average compression strength of cylinders shall not be less than 1700 psi at seven days, and 2300 psi at 28 days.</p> (2) <u>Rigid Pipe</u> <p>Steel cylinder pipe prestressed, the average compressive strength of cylinders shall not be less than 3000 psi at seven days, and 4500 psi at 28 days. Steel cylinder pipe, double wrapped shall not be less than 3000 psi at seven days, and 4500 psi at 28 days.</p> (b) <u>Mortar Coating and Concrete for Prestressed Pipe</u> <ol style="list-style-type: none"> (1) <u>Semi-Rigid Pipe</u> <p>Steel pipe and steel cylinder pipe, single wrap, pretensioned, the average compression strength of cylinders shall not be less than 3000 psi at seven days, and 4500 psi at 28 days.</p> (2) <u>Rigid Pipe</u> <p>Steel cylinder pipe prestressed, and steel cylinder pipe, double wrap pretensioned, the average compressive strength of cylinders shall not be less than 3000 psi at seven days, and 4500 psi at 28 days.</p>
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	<p>(c) To conform to these requirements (a and b above), the average of any five (5) consecutive strength tests of the laboratory cured specimens shall be equal to or greater than the specified strength, and no more than 20% of the strength test shall have values less than the specified strength. If any one cylinder falls below 80% of the specified strength at seven days, an extra cylinder from the same batch shall then be broken, and if the strength of this cylinder also falls below 80% of the specified strength, then the entire production represented by these cylinders will not be accepted for use until the results of the twenty-eight day test is known, and if it also falls below 80% of the specified strength, the above non-acceptance will become final. The expense of the required tests of cylinders and mortar shall be the responsibility of the Contractor.</p> <p>(d) Testing of Steel Pipe Cylinders (Hydrostatic Pressure Test): Each steel pipe cylinder, prior to embedment in cement mortar, or concrete, shall be hydrostatically tested under a water pressure which stressed the steel to a unit stress of at least 22,000 psi after the bell and spigot ends have been welded in place, utilizing companion bell and spigot test heads. While under this stress, the welded seams shall be hammered vigorously at one foot intervals with a one pound sledge hammer, and shall be thoroughly inspected.</p> <p>All parts of the cylinder showing leakage shall be marked for rewelding. After rewelding, such cylinders shall be subjected to another hydrostatic test as stipulated above. The costs of hydrostatic pressure test shall be at the Contractor's expense.</p> <p>(e) Testing of Fittings and Specials: The seams in angle pipe, short-radius bends and special fittings shall be welded in two or more passes, and each weld tested for tightness by the air-soap method or by the dye-penetrant method. However, if the fitting is fabricated from cylinders which have been previously tested hydrostatically, no further test is required for seams so tested. Hydrostatic testing of fittings to 150% of the design operating pressure may replace the tests described above. Any defect revealed under any of the alternate test methods shall be rewelded, and the weld tested again. The cost of these tests shall be at the Contractor's expense.</p> <p>758.5 Marking, Handling and Delivery: New Subsection:</p> <p>(A) Marking: Identification markings, for each type of water pipe as specified herein, shall be placed on the pipes. These markings shall show the proper location of the pipe or special in the line by reference to layer drawings. All bends shall be marked on the ends with the angle of deflection and the plane through the axis of the pipe. All beveled pipe shall be marked with the amount of the bevel, and the point of maximum bevel shall be marked at the end of the spigot.</p> <p>(B) Handling and Delivery: All pipe shall be manufactured, handled, loaded, shipped, unloaded and stored at the job site in such a manner as to prevent any damage to the pipe. Any pipe section that becomes damaged shall be repaired as directed by the Engineer if, in his opinion, a satisfactory repair can be made. Otherwise, it shall be replaced with an undamaged section, at the Contractor's expense. Lifting from the inside of the pipe will not be permitted.</p>
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STEEL PIPE

759.1 GENERAL:

These specifications apply to Steel pipe intended for use in water supply pipelines that carry water under pressure. Steel pipe is specified as follows:

Steel pipe shall be designed, manufactured and tested in accordance with AWWA C-200.

Steel pipe and fittings may be furnished in pipe diameters of six (6) inches and larger.

Pipe shall be designed by the methods described in AWWA C-200 and AWWA Manual M11, to resist the internal pressures and external loading conditions designated on the approved plans or in the project specifications.

Trench excavation, backfilling and compaction shall be in accordance with Section 601 unless otherwise specified in the plans and specifications. For Steel Pipe with a flexible coating the backfill pipe zone material shall consist of Granular Material, maximum 3/4 inch size.

As an option, the backfill in the pipe zone may be Controlled low strength material (CLSM) in accordance with Section 728 and placement per Section 604.

759.2 LINING AND COATING OPTIONS:

(A) Cement mortar lining and cement mortar coating shall be in accordance with AWWA C-205.

(B) Polyurethane coatings for interior and exterior of steel pipe shall be in accordance with AWWA C-222. The MDFT shall be 20 mils. on the interior lining and 25 mils. on the exterior coating.

(C) Polyethylene tape coating shall be in accordance with AWWA C-214. The total thickness of the tape coating shall be minimum 50 mils for pipe up to 54 inches diameter and minimum 80 mils for pipe 54 inches diameter and larger.

(D) Liquid-Epoxy coating systems for the interior and exterior of steel water pipelines shall be in accordance with AWWA C-210. Interior lining will be applied in one or two coats MDFT of 16 mils.

All linings for potable waterlines shall be NSF approved.

759.3 MANUFACTURE:

The contractor shall submit design calculations, a tabulated layout schedule, and details of specials and fittings to the Engineer for review and approval.

When specified in the project specifications, the manufacturer shall furnish all samples, test reports, test specimens and perform tests as provided in AWWA C-200 or AWWA manual M11.

Standard pipe shall be furnished with rolled-groove bell and spigot rubber gasket joints. Restrained joints shall be lap-welded slip joints with the bell formed by cold formed expanded dies.

Unless otherwise specified, fabricated steel pipe shall be manufactured in uniform lengths to fit the pipeline alignment shown on the plans, subject to a maximum length of 40 feet. For Steel Pipe with flexible coatings the pipe length may be 60 foot maximum, subject to the Manufacturer's recommendations. Shorter lengths may be furnished to facilitate special conditions.

The Contractor shall submit an affidavit of compliance from the manufacturer that the pipe and fittings furnished comply with all applicable provisions of AWWA C-200 or AWWA Manual M11.

The Engineer or his representative shall be allowed access to the manufacturer's plant for the purpose of inspecting the pipe and fittings.

COATING CORRUGATED METAL PIPE AND ARCHES

760.1 GENERAL:

Corrugated metal pipe, pipe arches, and connectors to be used or furnished under this specification shall be manufactured and inspected in conformance with the requirements of AASHTO M-36, and as hereinafter specified. The size, type, and wall thickness of the pipe to be furnished shall be as specified on the project plans or specifications.

760.2 MATERIALS:

Corrugated metal products covered by this specification shall be plain galvanized conforming to the requirements of AASHTO M-36 as modified herein.

The types of bituminous coated pipe shall be as specified by the standard details or special provisions. In addition to the types listed in AASHTO M-190, there will be Type E.

Type E Pipe - Corrugated Metal Pipe with Smooth Metal Liner: The pipe shall be manufactured as per AASHTO M-36, Type 1A except that the lock seam shall be on the tangent of the helical corrugation. The ends of each pipe shall be reformed with two annular corrugations for joining the pipes with approved band couplers. The minimum thickness of the pipe shell shall be as required to support external load with no credit for load carrying support given to the liner. The minimum thickness for the liner shall be 22 gauge (0.034 inches).

Municipality	Supplements
PH:	<p>760.2 MATERIALS: all the following paragraphs:</p> <p>The type of CMP that will be allowed in the City of Phoenix are “Aluminized, Type 2” & “Type F- Concrete lined as listed in AASHTO M-190.</p> <p>Type F Pipe - Concrete Lined Pipe: The pipe shall be uniformly coated on the outside as required for Type A pipe. The entire inside shall be lined with Portland cement concrete. The lining shall be plant applied, in a manner approved by the Engineer, such that a homogeneous, non-segregated concrete lining with mechanical trowel finish is produced. The lining shall have a minimum thickness of 1/8 inch above the crest of the corrugation.</p> <p>Portland cement used shall be in accordance with MAG Section 725 and, in no case, be less than 564 pounds per cubic yard of cement. Sand shall be as per Section 701 and the size and gradation shall be as specified for Portland cement concrete.</p>

Municipality	Supplements
SC:	<p>760.2 MATERIALS: <i>Delete text of subsection and insert the following:</i></p> <p>Corrugated metal products covered by this specification shall be either plain galvanized conforming to the requirements of AASHTO Designation M-218 or aluminized conforming to the requirements of AASHTO Designation M-274, except as modified herein.</p> <p>Bituminous coatings will not be allowed.</p> <p>AASHTO M-190 will be modified to include Type E pipe.</p> <p>Type E pipe - Corrugated metal pipe with Smooth Metal Liner: This pipe shall be manufactured per AASHTO M-36, Type 1A except that the lock seam shall be on the tangent of the helical corrugation. The minimum thickness of the pipe shell shall be as required to support the external load with no credit for load carrying given to the liner. The minimum thickness for the liner shall be 18-gage (0.052 inch).</p> <p>Concrete lined corrugated metal pipe shall conform to the requirements of ASTM A-849, except as modified herein.</p>

	<p>(A) Composition - concrete for the lining shall be composed of cement, fine aggregate and water that are well-mixed and of such consistency as to produce a dense, homogenous, non-segregated lining.</p> <p>(B) Cement - Portland cement shall conform to the requirements of ASTM C-150 Type II, low alkali.</p> <p>(C) Aggregates - aggregate shall conform to MAG Section 701.</p> <p>(D) Mixture - the aggregate shall be sized, graded, proportioned and thoroughly mixed with such proportions of cement and water as will produce a homogenous concrete mixture of such quality that the pipe will conform to the design requirements of this specification. In no case, however, shall the proportions of Portland cement, blended cement or Portland cement plus pozzolanic admixture be less than 564 lb./cu. yd. of concrete.</p>
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760.3 BASE METAL, SPELTER AND FABRICATION:

The nominal pipe diameter shall meet the tolerances of this specification. Elliptical pipe, when specified, shall be shaped after fabrication and coating have been completed.

Helically Corrugated Metal Pipe: The pipe shall be fabricated from flat sheets in coils. The base metal, spelter coating, method of sampling, accepted brands of metal, sheet manufacturer's certified analysis and guarantee, workmanship, marking, inspection and rejection, shall meet the requirements of AASHTO M-36. Structures furnished shall be either full circle, or pipe-arch in accordance with Table 4 of AASHTO M-36, or other shape as shown on the plans. The pipe dimensions shall conform to AASHTO M-36 in all respects, except that the corrugations shall be helical instead of annular. The thickness of the galvanized metal shall be in accordance with project plans or specifications as otherwise specified. Pipe with helical corrugations shall have a continuous lock or weld seam extending from end to end of each length of pipe. The seams shall be fabricated in such a manner that they will not affect the shape or nominal diameter of the pipe and so that they will not create an element of weakness in the pipe.

Spiral Rib Metal Pipe: The pipe shall be fabricated from flat sheets in coils. The base metal, spelter coating, method of sampling, accepted brands of metal, inspection and rejection, shall meet the requirements of AASHTO M-36. Structures furnished shall be full circle on sizes of 18 inch and above as shown in Table 4 of AASHTO M-36. The pipe shall be fabricated with helical rectangular ribs projecting outwardly from the pipe wall with a continuous lock seam extending from end to end of each length of pipe. Spiral Rib Pipe shall consist of two rectangular ribs and one half-circle rib equally spaced between seams. Rectangular ribs shall be 3/4 inch wide by 1 inch high. The half-circle rib diameter shall be 1/2 inch and shall be midway between the rectangular ribs. Maximum rectangular rib spacing shall be 11 1/2 inches. The thickness (gage) of the metal shall be in accordance with project plans and/or specifications or as otherwise specified.

Municipality	Supplements
SC:	<p>760.3 BASE METAL, SPELTER AND FABRICATION: <i>Add the following paragraphs:</i></p> <p>Concrete Lined Corrugated Metal Pipe: The following items in addition to those described in Helically Corrugated Metal Pipe apply. The lining shall have a minimum thickness of 1/4 inch above the crest of the corrugations. The lining shall be plant applied by a machine traveling through a stationary pipe. The rate of travel of the machine and the rate of concrete placement shall be mechanically regulated so as to produce a homogenous non-segregated lining throughout. The lining machine shall also mechanically trowel the concrete lining as the unit moves through the pipe.</p> <p>Each metal pipe section shall be fabricated with a minimum of two annular re-rolled corrugations at each end for the purpose of joining the pipes with an approved coupling band. Smooth metal lined corrugated metal pipe shall be re-rolled with liner intact to crimp the liner and shell in the annular configuration.</p>

760.4 COUPLING BANDS:

Watertight joints shall be fabricated for corrugated metal pipe by the use of galvanized couplers or connecting bands, bituminous coated where required, with each band overlapping by at least 2 inches. Corrugated coupling bands shall be constructed and connected as specified in AASHTO M-36, except as otherwise required herein. The couplers or bands shall be manufactured of material 2 gages lighter than the gage specified for the pipe material, shall have corrugations or dimples to match the pipe

corrugations or end treatment or may be flat, and shall be fastened with bolts. Dimpled coupling bands shall be 10 1/2 inches wide for diameters 12 through 60 inches, and 17 inches wide for diameters above 60 through 96 inches. The 10 1/2 wide bands shall have 2 rows of dimples of not less than 7 dimples per row, and the 17 inch wide bands shall have 4 rows of dimples of not less than 7 dimples per row. The dimple arrangements shall be such that a maximum spread can be attained. The shape of the dimple shall be such that it shall, in general conform to the standard pipe corrugation. The connecting angles for dimpled coupling bands may be riveted as for standard corrugated coupling bands, or may have slotted angles. The bands shall be attached by means of 1/2 inch nominal diameter carriage bolts. Two bolts are required for pipe up to 36 inches in diameter, 3 bolts for 36 through 60 inch diameters and 5 bolts for pipes above 60 inches in diameter. Plain flat coupling bands and spiral rib flange bands shall have the same width and number of bolts as specified above. Flat coupling bands having a single circumferential corrugation rolled in each edge to match a similar corrugation in the end of each pipe may be 10 1/2 inches wide regardless of pipe diameter and shall be fastened with 2 bolts.

When flanges are provided on the pipe ends, the coupling shall be made by interlocking the flanges with a preformed channel band or other band incorporating a locking channel not less than 3/4 inches in width. The depth of the channel shall be not less than 1/2 inch. The channel band shall have a minimum nominal thickness of 0.079 inches.

Municipality	Supplements
SC:	<p>760.4 COUPLING BANDS: <i>Delete text of subsection and add the following:</i></p> <p>Fabricated coupling bands shall meet the requirements of AASHTO M-36, except as modified herein. Metal bands may be manufactured of material two gages lighter than that gage specified for the pipe to a minimum thickness of 0.064 inch (16 gage).</p> <p>Coupling bands shall be one-piece for all pipe diameters to 48 inches. Pipe diameters larger than 48 inches shall use two-piece coupling bands. Coupling bands shall be a minimum 10 1/2 inches wide, formed with a minimum of two annular corrugations that are spaced to provide nesting of the second annular corrugation of each pipe.</p>

760.5 PERMISSIBLE VARIATIONS IN DIMENSION:

The internal diameter of 12 through 24 inch pipe shall not vary more than ± 1.5 percent from the design diameter. The internal diameter of 27 through 108 inch shall not vary more than ± 1 percent or 3/8 inch, whichever is greater from the design diameter.

Type D Pipe: The design diameter of the metal pipe before paving shall be the diameter shown on the plans plus 1/4 inch. The design diameter may vary as above.

Municipality	Supplements
SC:	<p>760.6 REPAIRS:</p> <p>Concrete Lined Corrugated Metal Pipe - The pipe shall be inspected for cracks after all backfilling of the pipe trench has been completed and accepted. The type of material used for crack repairs shall be submitted to the Engineer for approval prior to the start of any corrective work. Spalling, separations or offsets in the lining shall be repaired by approved methods using epoxy materials.</p> <p>All cracks, any part of which is 1/16 inch or more in width shall be repaired for their entire length. The crack shall be filled with an approved epoxy joint filling material that will bond the two faces of the crack. The finished interior surface of the pipe at the location where cracks are repaired shall be cleaned with any extraneous material removed, such that the surface matches the adjacent mechanically trowelled surface.</p>

STRUCTURAL PLATE PIPE, ARCHES, AND PIPE ARCHES

761.1 GENERAL:

Structural plate pipe, arches, and pipe arches shall be of the sizes, gages, and dimensions designated on the plans or in the special provision and as specified herein.

761.2 MATERIALS:

Plates, nuts and bolts shall conform to the specifications of AASHTO M-167.

Galvanized surfaces which are damaged shall be repaired in accordance with the provision in Section 771.

Bituminous coating shall conform to the provisions of AASHTO M-190.

Damaged bituminous coatings shall be repaired by the Contractor at his expense by applying bituminous material conforming to AASHTO M-190.

761.3 IDENTIFICATION:

The gages of structural plates will be identified on the plans in accordance with the following:

Each installation will be designated not only by size, but also by symbol indicating the number and gage of plates required. Thus, (412-18) will be used to designate an installation for 1 plate length composed of 4, 12 gage plates and 1, 8 gage plate, the heaviest to be placed in the invert.

761.4 DISTORTION:

In advance of placing backfill material around circular structural plate pipes, the pipe shall be distorted.

Distortion may be performed either at the fabricating shop or in the field.

If the plates are distorted in the fabricating shop, the plates shall be distorted to provide an increase in the vertical diameter of the pipe, after assembly, of approximately 5 percent for the full length. Plates shall be marked in order to assure that they will be placed in proper position.

If the pipes are distorted in the field the method of distortion shall conform to the details shown on the plans. The vertical diameter shall be increased the approximate percentages listed in the following table, throughout that portion of the pipe between shoulder lines.

Pipes using 1 or 3 gage top and side plates - 1 percent

Pipes using 5 or 7 gage top and side plates - 2 percent

Pipes using 8, 10, or 12 gage top and side plates - 3 percent

Between the shoulder lines and the outer ends of the pipe the distortion may decrease uniformly to zero.

RUBBER GASKETS FOR CONCRETE PIPE

765.1 GENERAL:

The joints of concrete pipe shall be O-ring rubber gasket joints conforming to ASTM C-361 except the composition and properties of the rubber gaskets shall be as follows:

All rubber gaskets shall be extruded or molded and cured in such a manner as to be dense, homogeneous, and free from porosity and other imperfections. The tolerance for any diameter measured at any cross section shall be \pm one-thirty-second inch. All gaskets shall be manufactured from a synthetic rubber compound in which the elastomer is chloroprene (ASTM-SAE Designation Type SC) exclusively. Said compound shall contain not less than 50 percent by volume of neoprene, shall contain no deleterious substances, and shall conform to Table 765-1.

TABLE 765-1		
RUBBER GASKETS		
Physical Properties	Value	Method of Test
Tensile strength, Min. psi	1500	ASTM D-412
Elongation at break, Min. %	425	ASTM D-412
Shore durometer hardness, Type A.(1)	40-60	ASTM D-2240
Compression set, Max. % of original deflection, (2)	20	ASTM D-395
Accelerated aging, tensile strength, % (3)	80	ASTM D-572
Max. increase over original shore durometer value after accelerated aging	8	ASTM D-2240
Specific Gravity	0.95-1.45 ± 0.05	ASTM D-297

Notes:

- (1) Pipe manufacturer shall select value suitable to type of joint.
- (2) Use Method B, except disc shall be 1/2 inch long section of rubber gasket stock.
- (3) Percent of tensile strength, after aging by the oxygen-pressure chamber (96 hours, $158 \pm 1.8^{\circ}\text{F}$. 300 ± 15 psi), of the tensile strength before aging.

It is the intent of these specifications that the gasket container shall be a preformed rectangular groove so constructed that when 2 pipes are joined together the rubber gasket shall be compressed and for all practical purposes substantially fill and be largely confined within the rectangular groove.

The Contractor shall submit for approval details of the shape and size of the gaskets he proposes to furnish. The Contractor shall submit certified test results in triplicate showing the physical properties of the materials used in the manufacturer of gaskets.

STRUCTURAL AND RIVET STEEL, RIVETS, BOLTS, PINS, AND ANCHOR BOLTS

770.1 GENERAL:

All steel, unless otherwise designated on the plans or in the special provisions, shall conform to the requirements of ASTM A-36.

Report of Tests: Before fabrication, the Contractor shall furnish to the Engineer a certified mill report in triplicate, for each identifiable melt of steel or iron from which the material is to be fabricated. The report shall include the chemical and physical tests required by the ASTM specifications.

Additional Tests: The Contracting Agency reserves the right to require and to make additional mill and laboratory tests. The number of such additional tests will be limited as follows, except that in the case of failure of the material to comply with the ASTM requirements, more tests will be made:

Structural steel, 1 complete test for each heat or each 10 tons of identifiable stock. Rivets, 1 complete test for each size. Bolts, 1 complete test for each lot.

Identifiable stock is material for which authentic records of the chemical and physical properties are available.

Test specimens shall be furnished, cut, and machined in accordance with the ASTM specification, for the material to be tested, as referred to herein. Test specimens shall be furnished and machined by the Contractor at no additional cost to the Contracting Agency.

Mill Tolerances: Rolling and cutting tolerances, permissible variations in weight and dimensions, defects and imperfections shall not exceed the limits for structural steel contained in ASTM A-6.

Stock Material: When the Contractor proposes to use material already in stock, he shall notify the Engineer of such intention at least 10 days in advance of beginning fabrication, to permit sampling and testing.

770.2 STRUCTURAL STEEL:

Stock Materials: The Contractor shall select the material he wishes to use from stock. The Contractor shall furnish 3 certified mill reports for each of the heat numbers. Two samples shall be taken by a representative of the Engineer from each heat number, one for the tension test and one for the cold bend test. If the heat numbers cannot be identified, the representative of the Engineer shall select random test specimens from the unidentifiable heats. The number of such test specimens shall be at the discretion of the Engineer. The cost of all tests on stock material shall be borne by the Contractor.

High Strength Low-Alloy Structural Steel: The material shall conform to the requirements of ASTM A-242, A-572/A-572M, A-606, A-607 or A-653 Grades C, D, or E as specified in the special provisions.

Copper Bearing Structural Steel: Copper bearing structural steel shall conform to the requirements of ASTM A-36, A-570, A-611, or A-653 as specified in the special provisions.

770.3 RIVETS:

Stock Material: Rivets taken from identifiable stock shall be accepted by the Engineer in accordance with this specification.

Rivets from unidentifiable stock, for which authentic records of the chemical and physical properties are not available, shall not be used except where shown on the plans or when approved by the Engineer.

High-Strength Structural Rivet Steel: The material shall conform to the requirements of ASTM A-502.

Structural Rivet Steel: The material shall conform to the requirements of ASTM A-502, except that the test specimen shall be bent upon itself when performing the bend test.

770.4 BOLTS:

Unfinished Bolts: The bolts shall have square heads and square nuts unless otherwise specified. The bolts shall be long enough to extend entirely through the nut but not more than 1/4 inch beyond. Washers shall not be furnished unless specified.

Steel bolts shall conform to the requirements of ASTM A-307, except that steel manufactured by the acid Bessemer process shall not be used.

High Strength Bolts: High strength bolts shall conform to the provisions of the specification for the design, fabrication and erection of structural steel for buildings of the AISC.

770.5 ANCHOR BOLTS:

Anchor bolts shall be manufactured from steel conforming to ASTM A-36 or A-307.

770.6 MILD-STEEL FORGINGS FOR STRUCTURAL PURPOSES:

Steel forgings shall be made from steel of forging quality and shall conform to the requirements of ASTM A-668. They shall be Class C forgings with a maximum carbon content of 0.35 percent and shall be given a thorough annealing. The metal shall have a minimum Brinell hardness number of 130, and a maximum of 190, when tested in accordance with ASTM E-10.

GALVANIZING

771.1 GENERAL:

Materials shall be hot-dip galvanized and the weight and uniformity of coating determined in accordance with the standard specifications given in Table 771-1.

TABLE 771-1		
GALVANIZING SPECIFICATIONS		
Material	ASTM Spec.	Wt. of Coating Oz./Sq. Ft. (Min.)
Corrugated Metal Pipe	A-929	1.80
Flat Steel or Iron Sheets	A-653, A-924	1.25
Iron or Steel Wire	A-116	.80
Chain Link Fabric	A-392	1.20
Barbed Wire	A-121	.50
Steel Pipe - Rails and Posts	A-53	1.80
Structural Shapes, Tie Rods, Ornamental Iron Railings, Handrails, Manhole and Catch Basin Steps, and Curb Armor	A-123	2.00
Bolts, Nuts, Washers, Anchor Bolts, Packing Spools, Gray Iron and Malleable Iron Castings and Steel Castings	A-153	1.25

771.2 WORKMANSHIP:

The galvanizing shall be applied in such a manner that the spelter will not peel off. The finished product shall be free from blisters and excess spelter, and the coating shall be even, smooth, and uniform throughout. Machine work, die work, cutting, punching, bending, welding, drilling, thread cutting and other fabricating shall all be done as far as is practicable before the galvanizing. No member shall be galvanized which is out of alignment. All members (nuts, bolts, washers, etc.) shall be galvanized before a structural unit is assembled. All uncoated spots or damaged coatings due to poor workmanship, rough handling, or any other reason shall be cause for rejection.

771.3 TEST COUPONS:

Test coupons for determining the quality of the galvanizing shall be wired to the materials to be galvanized before immersion in such a manner as to represent the amount of coating deposited on the materials.

771.4 REPAIR OF GALVANIZED SURFACES:

Unless otherwise specified, where galvanized surfaces are field or shop cut, broken, burned or abraded, thus breaking the galvanizing, the locations thus damaged shall be repaired to the satisfaction of the Engineer with zinc dust-zinc oxide coating conforming to AASHTO M-36.

CHAIN LINK FENCE

772.1 GENERAL:

All material shall be new and, upon request, the Contractor shall furnish to the Contracting Agency, a certification of inspection stating that the materials have been manufactured, sampled, tested and inspected so as to meet the requirements for its type as specified below.

772.2 POSTS, RAILS AND BRACES:

Posts, rails and braces shall be constructed of pipe in conformance with types A, B or C below. Unless specifically designated by type in the plans or specifications, the Contractor may utilize any of the three types. The posts and rails in this section will cover fencing up to 12 feet in height with post spacing not to exceed 10 feet. The nominal outside dimensions and minimum weights shall be in accordance with Table 772-1. The manufacturer or his representative shall legibly mark each length of pipe by rolling, stamping or stenciling to identify the product by product name, ASTM standard, etc. and the country of manufacture.

Type A: Pipe shall be black steel, welded or seamless, hot-dipped zinc coated, manufactured in conformance to ASTM F-1083, plain end, standard weight (schedule 40). The hot-dipped zinc coating (galvanized) shall be applied both inside and outside with not less than 1.8 ozs. per square foot \pm 0.1 ozs.

Type B: Steel used in the manufacturing of the pipe shall be hot-rolled strip steel in compliance with ASTM A-569 having a minimum yield strength of 50,000 psi. The pipe will be manufactured by electric welded cold-formed process per ASTM A-500. The exterior surface will be triple coated and the interior surface single coated per ASTM F-1043. The triple coated external surface shall be hot-dipped zinc coated (galvanized) having a weight of not less than 1.0 ozs. per square foot \pm 0.1 ozs., followed by a chromate conversion coating, having a weight not less than 1.05 micro ounces per square foot \pm 0.353 micro ounces (30 micrograms per square inch \pm 15 micrograms) and an acrylic coating having a thickness of 0.0005 inches \pm 0.0002 inches. The internal surface shall be coated with a zinc base paint having a 90% zinc powder loading and having a minimum thickness of 0.0005 inches.

Type C: Steel used in the manufacturing of the pipe shall be strip steel in compliance with ASTM A-653 Grade D having a minimum yield strength of 50,000 psi. Both sides of the strip shall be hot-dipped zinc coated (galvanized) per ASTM A-653 and A-924 having the weight of not less than 1.0 oz. per square inch \pm 0.1 oz. The zinc coating will form the first coat of a triple coated external surface and the final coat of the interior surface. The pipe will be manufactured by electric welded cold formed process per ASTM A-789. After manufacturing, the final two external coatings shall be a chromate conversion having a weight of not less than 1.05 micro ounces per square inch \pm 0.353 micro ounces and an acrylic coating having a thickness of 0.0005 inches \pm 0.0002 inches.

Municipality	Supplements
ME:	<p>GG. Section 772.2 – Modify the subsection as follows: ALL posts, rails and braces shall be Type A, unless otherwise specified on the plans or in the Special Provisions.</p> <p>HH. <u>SPECIAL NOTICE REGARDING STREET EXCAVATION BACKFILLING AND PAVEMENT REPLACEMENT:</u> The Contractor shall be responsible for backfilling and replacing pavement in all street excavations per the latest edition of the City of Mesa’s Policy Statement for Street Trench Backfilling and Pavement Replacement dated September 29, 1999. Copies of this policy statement are available at the Building Safety Desk, at no charge. SPECIAL ATTENTION IS CALLED TO THE POLICY STATEMENT REQUIREMENTS FOR TRANSVERSE TRENCHES. BACKFILL IN ALL TRANSVERSE TRENCHES SHALL BE ONE SACK CONTROLLED LOW STRENGTH MATERIAL PER MAG SECTION 728. A cash bond, as stipulated in the policy statement, will not be required for contract projects, but will be required for permit construction.</p> <p>I. <u>SPECIAL NOTICE REGARDING DRIVEWAY AND SIDEWALK RAMP CUTS IN EXISTING CURB AND GUTTER SECTION:</u> The City of Mesa no longer allows vertical, longitudinal cuts through the gutter section in order to install driveways or sidewalk ramps. In order to accomplish this work, the Contractor shall employ one of the following methods:</p>

	<ol style="list-style-type: none"> 1. Sawcut perpendicular to the flowline through the curb and gutter section at the limits of the section to be replaced, remove, and replace in entirety; or, 2. Saw through the curb section with the sawcut having a slope towards the gutter. At the face of the curb, the sawcut shall be flush with the gutter and at the back of the curb, one (1) inch above the gutter. Horizontal curb cut shall taper from sawcut to top of curb to establish wings in accordance with Detail M-42 (Commercial Driveway), M.A.G. 250 (Residential Driveway), and M.A.G. 231 through M.A.G. 234 (Sidewalk Ramps).
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772.3 CHAIN LINK FABRIC:

Chain link fabric shall conform to the requirements of ASTM A-392 (Zinc-Coated) or ASTM A-491 (Aluminum-Coated). The coating process must leave the fabric completely free of barbs, icicles, or other projections which might be hazardous. The wire used in the manufacture of the fabric shall be 11 gage for all fence 60 inches or less in height and shall be 9 gage for all fence over 60 inches in height unless otherwise specified.

All chain link fabric shall be woven into approximately 2 inch mesh. Fabric less than 60 inches wide shall have knuckled finish on the top edge, and twisted and barbed finish on the bottom edge. Fabric 60 inches or greater in width shall have twisted and barbed finish on both edges. Barbing shall be done by cutting the wire on the bias.

772.4 TENSION WIRES AND FABRIC TIES:

Tension wires shall be at least 7 gage galvanized coil spring steel wire per ASTM A-824. Ties used to fasten the fabric to posts, rails, and gate frames shall be not smaller than 11 gage galvanized steel, 6 gage aluminum wire, or approved non-corrosive metal bands.

Tension bars used in fastening fabric to end and corner posts and gate frames shall be galvanized high carbon steel bars not smaller than 3/16 inch x 3/4 inch.

TABLE 772-1					
FENCE MEMBER SIZES & WEIGHTS					
USE	FENCE HEIGHT (Feet)	NPS DESIGNATOR	OUTSIDE DIAMETE R (Inches)	WEIGHT (Lb/Lf Minimum)	
				TYPE A Schedule 40	TYPE B and C
FENCE POSTS					
End, corner, slope, pull and strain posts	Less than 6	2	2.375	3.65	3.12
	6 and over but less than 9	2 1/2	2.875	5.79	4.64
	9 and over but not over 12	3 1/2	4.000	9.11	6.56
Line posts	less than 6	1 1/2	1.900	2.72	2.28
	6 and over but less than 9	2	2.375	3.65	3.12
	9 and over but not over 12	2 1/2	2.875	5.79	4.64
GATE POSTS					
Single swing gates 6 feet or less in width or double swing gates 12 feet or less	less than 6	2	2.375	3.65	3.12
	6 and over but not over 12	3 1/2	4.000	9.11	6.56
Single swing gates over 6 feet but not over 13 feet in width or double swing gates over 12 feet but not over 26 feet in width	—	3 1/2	4.000	9.11	6.56
Single swing gates over 13 feet but not over 18 feet in width or double swing gates over 26 feet but not over 36 feet in width	—	6	6.625	18.97	—
Single swing gates over 18 feet in width or double swing gates over 36 feet in width	—	8	8.625	28.55	—
OTHER MEMBERS					
Top rail and braces	—	1 1/4	1.666	2.27	1.84
Frame for gates	—	1 1/2	1.900	2.72	2.28
Stiffeners for gates	—	1 1/4	1.666	2.27	1.84

Notes to Table 772-1:

- All unit weights shall be subject to the standard mill tolerance of ± 5 percent.
- Posts shall be fitted with tops designed so as to fit securely over the posts and carry a top rail where specified. They shall have a total length of not less than the depth of the concrete footings, as specified, plus the length required above ground. Where no top rail is required, pipe posts shall be fitted with suitable caps.
- Top rail shall be furnished in random lengths of approximately 20 feet where required.

772.5 TRUSS OR TENSION RODS:

Truss or tension rods used in trussing gate frames and line posts adjacent to end, corner, slope or gate posts shall be adjustable 3/8 inch diameter galvanized steel rod. When used in trussing line posts, adjustment shall be provided by means of galvanized, turnbuckle or other suitable tightening devices.

772.6 FITTINGS:

Fittings shall conform to ASTM F-626.

Fittings, hardware, nuts and bolts shall be galvanized.

Couplings to connect the individual lengths of top rail shall be of the outside sleeve type at least 7 inches long. The bore of the sleeves shall be sufficiently true to maintain adjacent lengths of rail in alignment.

Extension arms for barbed wire on pipe posts shall be of 13 gage steel or heavier, single piece construction and a type that can be attached to the tops of the posts. Extension arms shall carry 3 wires at approximately 5 1/2 inch centers in a plane approximately 45 degrees from the vertical, inclined as shown on the plans or as directed by the Engineer.

772.7 BARBED WIRE:

Barbed wire shall be 4 point pattern, composed of 2 strands of 12 1/2 gage galvanized steel wire with barbs spaced 5 inches apart and shall conform to ASTM A-121.

BRICK AND CONCRETE MASONRY UNITS (BLOCKS)

775.1 BRICK:

Brick shall be whole, sound, and hard burned and shall give a clear ringing sound when struck together. They shall be uniform in quality and shall be culled or sorted before delivery to the work.

775.1.1 MANHOLE BRICK:

Sewer and water manhole brick shall conform, except for dimensional tolerances, to the requirements of ASTM C-32, Grade MM.

Manhole brick shall conform to Table 775-1.

TABLE 775-1			
MANHOLE BRICK DIMENSIONS			
Brick	Inches Depth	Inches Width	Inches Length
Standard Size	2 1/4	3 1/2	7 1/2
Allowable Variations	±1/8	±1/8	±1/4

The following paragraphs shall be added to the section on visual inspection:

No individual brick shall be rejected unless it shows visual evidence of major cracking. A major crack is defined as one that has at least one complete separation, for a distance of 1 3/4 inches, through the brick in any direction, including any cored area. Such a crack shall be regarded as affecting the serviceability of the brick and shall be rejected and not used in the structure.

Fifty bricks may be sampled at random intervals from any cube for visual inspection. Of the 50 samples, 45 must pass visual inspection for major cracks. Should less than 45 pass, the cube of brick shall be rejected and the brick must not be used in the structure.

775.1.2 BUILDING BRICK:

Building brick shall conform to the requirements of ASTM C-62, grade MW.

775.1.3 FACING BRICK:

Facing brick shall conform to the requirements of ASTM C-216, Grade MW, Type FBS. The size, color, and texture shall be as specified on the plans or as approved by the Engineer.

775.2 CONCRETE MASONRY UNITS:

Unless otherwise noted on the plans or special provisions, concrete masonry units shall conform to ASTM C-90, Normal Weight, Type I with a minimum compressive strength of 1900 psi.

The units shall be fully cured and shall have been made not less than 28 days prior to delivery.

The moisture content at the time of delivery shall not exceed 30 percent of the minimum absorption value of the units. The Contractor shall provide any protection he deems necessary to maintain the units in this condition until time of use.

The linear change from saturated to cool oven dry shall not exceed 0.0054 inches per linear foot or 0.045 of 1 percent conducted in accordance with test method in ASTM C-426.

The units shall be made with normal weight aggregate conforming to ASTM C-33.

The nominal size of the units shall be as indicated on the plans. The overall dimensions for width, height and length shall differ by not more than $\pm 1/8$ inch from the specified standard dimensions. Standard dimensions of units are the manufacturer's designated dimensions. Nominal dimensions of units are equal to the standard dimensions plus the thickness of one mortar joint.

No less than 5 samples of the units shall be submitted to the Engineer for approval and to show the full variance of texture and full range of color. Units used in the work shall match the approved samples. These samples may be tested for strength.

All units shall be sound and free of cracks or other defects that would interfere with the proper placing of the unit or would significantly impair the strength or permanence of the construction. When units are to be used in an exposed setting, the face or faces that are to be exposed shall not show chips or cracks, not otherwise permitted, or other imperfections when viewed from a distance of not less than 6 feet under diffused lighting.

Units that are intended to serve as a base for plaster or stucco shall have a sufficiently rough surface to afford a good bond.

MASONRY MORTAR AND GROUT

776.1 GENERAL:

Masonry mortar and grout shall consist of a mixture of cementitious material and aggregate to which sufficient water has been added to bring the resulting mixture to the desired consistency.

Table 776-1 and 776-2 indicates the average compressive strength obtained when the cementitious material, aggregate, and water (the required amount to provide a flow of 110±5 percent) are combined in the proportion shown in Table 776-3 and 776-4.

The mortar or grout to be used will be designated by class in the special provisions and the correct proportions of cementitious materials and aggregate will be combined with the minimum amount of water to provide a workable mixture.

Retempering of the mortar or grout will not be a standard practice and the Engineer's approval will be required for any exception.

TABLES 776-1 & 776-2			
MASONRY MORTAR AND GROUT COMPRESSIVE STRENGTH			
Table 776-1 Masonry Mortar		Table 776-2 Grout	
Type	Compressive Strength 28 Days (psi)	Type	Compressive Strength 28 Days (psi)
A	5500	Fine Grout	2500
B	5000	Coarse Grout	2500
C	4000		
D	3000		
M	2500		
S	1800		

TABLE 776-3			
MASONRY MORTAR PROPORTIONS BY VOLUME			
Type	Portland Cement	Hydrated Lime	Aggregate ASTM C-144
A	1	0	1
B	1	0	1 1/2
C	1	0	2
D	1	0	2 1/2
M	1	1/4	2 1/4 to 3
S	1	1/2	2 1/4 to 3

*Masonry cement type S may be substituted for the cementitious material. Prior approval of the Engineer is required.

TABLE 776-4			
GROUT FOR REINFORCED MASONRY PROPORTIONS BY VOLUME FOR FIELD BATCHING			
Type	Portland Cement	Fine Aggregate (ASTM C-404)	Coarse Aggregate (ASTM C-404)
Fine Grout	1	2 1/4 to 3	0
Coarse Grout	1	2 1/2	1 to 2

776.2 PORTLAND CEMENT:

The cement used shall conform with Section 725. For volumetric proportioning an unopened sack of cement weighing 94 pounds shall be considered as having a 1 cubic foot volume.

In proportioning the cement, it shall be measured loose, without shaking or compacting, in measuring devices of known capacity.

776.3 AGGREGATE:

The aggregate used shall conform with Section 701. It shall be approved by the Engineer prior to being utilized on the job. Any change of course will require additional approval or this neglect will be considered as sufficient cause for rejection of work.

In proportioning the aggregate, it shall be measured damp, loose without shaking or compacting, in measuring devices of known capacity.

776.4 MASONRY CEMENT:

Masonry cement used shall conform to ASTM C-91 with the exception that the average compressive strength shall not be less than 2500 psi at 28 days.

776.5 HYDRATED LIME:

Hydrated lime used shall conform to ASTM C-207, Type S.

776.6 WATER:

The water used shall conform to section 725.

776.7 ADMIXTURES:

Admixtures, unless prescribed in the special provisions, will not be used without prior approval of the Engineer.

776.8 TESTS:

776.8.1 Mortar: If in the opinion of the Engineer there is sufficient cause to question the quality of the mortar being utilized, random field test in accordance with ASTM C-780 Annex A-1 and A-6 will be performed. For this area, the penetration of the cone penetrometer correlating to a flow of 110 ± 5 percent is 40 ± 3 mm.

776.8.2 Grout: If required, tests shall be performed in accordance with Uniform Building Code Standard No. 24-23 Section 24.2301.

LUMBER

778.1 GENERAL:

Unless otherwise specified or shown on the plans, all lumber shall be Douglas Fir or graded pine and shall be selected as to grade and shall conform in all particulars to the standard grading and dressing rules of the West Coast Lumber Inspection Bureau.

Plywood shall be not less than 3 ply, manufactured and graded in accordance with the standard grading rules of the APA.

Lumber for uses listed shall not be lower than the following grades:

Uses	Grade
(A) Permanent Construction, such as bridges and culverts.	Select Structural, for beams and stringers; Construction, for balance of structure.
(B) Minor permanent construction, such as fences, guard rails and posts, pavement headers, bulkheads, retaining structures, etc.	Construction.
(C) Falsework and studs, and wales for formwork.	Construction, for framing, beams, or timbers.
(D) Form sheeting for nonshowing surfaces of concrete.	Standard, for boards; shiplap; or any grade of plywood.
(E) Form sheeting for showing surfaces of ornamental concrete.	C and Better Industrial clear; concrete form grade of plywood; or overlay plywood.
(F) Form sheeting for curved soffits of bridge & tunnel arches, plastered or unplastered.	Select Merchantable, board; concrete form grade of plywood; or overlay plywood.
(G) Soffits of beams and girders and slabs between beams and girders; for beam and girder sides, except ornamental concrete; and for headwalls or endwalls of culverts or covered conduits.	Concrete form grade of plywood or overlay plywood.
(H) Form sheeting for showing surfaces of channel walls or interior surfaces, except floors; for covered conduit and all other showing surfaces not specified above.	Tongue and groove flooring equal to C and Better flat grain; concrete form grade of plywood; or overlay plywood.
(I) All other lumber.	Construction.

778.2 REDWOOD:

Redwood lumber shall be selected as to grade and shall conform in all particulars to the standard specifications for grades of California Redwood of the California Redwood Association.

Redwood lumber for the uses listed shall not be lower than the following grades:

Uses	Grade
(A) Bridges, culverts, and guardrail posts	Dense Structural.
(B) All other Redwood Lumber	Foundation.

778.3 GRADE MARKING:

Lumber. Each piece of lumber shall bear an official grade mark which, unless authorized otherwise, shall be the grade mark adopted by one of the following associations:

- (A) For Douglas Fir and Pine -The West Coast Lumber Inspection Bureau or other agency approved by the Engineer.
- (B) For Redwood -The California Redwood Association.

Plywood: Each sheet of plywood shall bear the official stamp of the APA stating the grading of the sheet.

WOOD PRESERVATIVES

779.1 GENERAL:

This work shall consist of treating lumber, timber, and piling. Lumber, timber, and piling to be treated shall conform to the requirements of the specification of the AWP and as specified herein.

Where practical, lumber to be treated shall be cut to size and framed, prior to treatment. Proper allowance for shrinkage in the sizes of lumber shall be made by the Contractor where it is necessary to meet definite dimensions shown on the plans.

779.2 OIL TYPE PRESERVATIVE TREATMENT:

Preservatives under this specification shall be creosote, creosote-coal tar solutions, creosote petroleum solutions, or pentachlorophenol in petroleum oils, conforming to AWP specifications and as specified by the Engineer.

Treatment: The treating operations shall conform to the applicable requirements of the AWP specifications.

Unless indicated otherwise on the plans or in the special provisions, the amount of preservative to be retained and the treating process to be used for the various types of service shall conform to the appropriate AWP specification.

Incising: Unless otherwise specified, timber to be treated under this specification that is 3 inches or more in nominal thickness and 4 inches or more in nominal width, shall be incised before treatment as a means of securing penetration of the preservative. If such thickness is less than 4 inches, the material may be incised on the wide faces only; otherwise, all 4 faces shall be incised.

779.3 WATER BORNE SALT PRESERVATIVES TREATMENT:

Preservatives under this specification shall conform to the requirements of AWP specifications unless otherwise approved in writing by the Engineer, but restricted to the following preservatives:

Chromated Zinc Chloride (CZC)

Tanalith (Wolman Salts)

Ammoniacal Copper Arsenite (Chemonite)

Chromated Zinc Arsenate (Boliden Salt)

Chromated Copper Arsenate (Erdalith)

779.4 FIELD TREATMENT OF CUT SURFACES:

When sawing or drilling is necessary after plant treatment, the cut surfaces shall be thoroughly brushed with 2 coats of the same kind of preservative in conformance with AWP specification. The maximum protection requirement specified therein shall be met in all instances.

TIMBER PILES

780.1 GENERAL:

All piles shall conform to the specifications of ASTM D-25 for clean peeled Class B piles.

STEEL PILES

781.1 GENERAL:

Steel piles furnished under this specification shall consist of structural steel shapes that fulfill the requirements prescribed for such material in ASTM A-36 and shall conform to the details and dimensions indicated by the plans and specifications relating directly thereto. The kind and type of steel piling to be used in the work shall be as indicated on the plans or special provisions.

781.2 MANUFACTURING:

Material for sheet piles shall not be made by the acid Bessemer process.

Steel sheet piling shall consist of standard interlocking sheet pile sections.

CONCRETE PILES

782.1 GENERAL:

Concrete piles furnished shall be precast, cast-in-place, prestressed, or centrifugal cast piles. The type to be furnished will be as specified on the plans or in the special provisions.

782.2 MANUFACTURING:

Concrete shall be mixed and proportioned in accordance with the requirements of Section 725. The class of concrete will be as stated on the plans or in the special provisions.

The manufacture of prestressed piles shall be performed in accordance with Section 506. Precast, cast-in-place and centrifugal cast piles shall be manufactured as specified in the special provisions.

STEEL CASTINGS

785.1 GENERAL:

The castings shall be true to pattern in form and dimension and free from pouring faults, sponginess, cracks, blowholes, or defects that would affect the service value of the casting.

Blowholes shall not have a depth sufficient to affect injuriously the strength of the castings. Minor defects which do not impair the strength of a casting may, with the approval of the Engineer, be welded by an approved satisfactory means and after welding, the castings shall be annealed, if so required by the Engineer. Castings which have been welded without the permission of the Engineer shall be rejected.

785.2 FINISH:

The dimensions of the finished castings shall be not less than the specified dimensions. Castings shall not be more than 7 1/2 percent overweight.

The bearing surfaces of rockers and rocker plates shall be machined accurately to the dimensions shown on the plans. The final surface shall be produced by a finishing cut. They shall be straight, smooth, and free from flaws.

Chemical analysis shall be performed in accordance with ASTM E-30.

785.3 TEST SPECIMENS:

Test coupons from which tension test pieces are prepared shall be attached to the castings where practicable. If, in the opinion of the manufacturer, the design of the casting is such that test coupons should not be attached thereon, the test coupons shall be cast attached to separate cast blocks. Sufficient coupons shall be cast to represent each lot with additional specimens for use in case retests should be required. A lot shall be considered as all castings in a melt which have constituted part or all of a heat-treatment charge.

Coupons shall remain attached until after the annealing process has been completed. Coupons may be identified by a representative of the Engineer. Where test coupons are cast separately from the castings, a representative of the Engineer may be present at the time of pouring to identify both coupons and castings. Coupons cast separately from the castings shall not be detached from the block to which they are fastened until identified.

The test coupons shall be of such size that test specimens can be machined to dimensions as specified in the ASTM procedure referred to herein. Where a specimen on machining, appears faulty and a true sample of the lot of castings to which it belongs, the representative of the Engineer may substitute another coupon of the lot in question. Test specimens shall be furnished and machined by the Contractor at no additional cost to the Contracting Agency.

785.4 RETESTS:

If the results of the physical test for any lot do not conform to the requirements specified, the manufacturer may reheat-treat such lot. Representative coupons shall be reheat-treated with the lot to serve as retest specimens.

785.5 HIGH-STRENGTH STEEL CASTINGS FOR STRUCTURAL PURPOSES:

Castings shall conform to ASTM A-148, Grade 80-50 except that the steel shall contain not less than 0.60 percent of manganese and not less than 0.20 percent of silicon.

785.6 MILD-TO-MEDIUM STRENGTH CARBON-STEEL CASTINGS FOR GENERAL APPLICATION:

Castings shall conform to ASTM A-27, Grade 65-35. The metal shall have a minimum Brinell hardness number of 130, when tested in accordance with ASTM E-10.

785.7 CASTINGS FOR HIGHWAY BRIDGES:

Steel castings for highway bridges shall conform to ASTM A-486 or AASHTO M-192.

BRONZE CASTINGS

786.1 GENERAL:

The castings shall be true to pattern in form and dimensions and free from defects that would affect the service value of the casting. Minor defects may be repaired with the approval of the Engineer. Chemical analysis shall be made in accordance with ASTM E-54.

786.2 PHYSICAL PROPERTIES:

Expansion and bearing plates shall conform to the physical properties as required in ASTM B-22, for alloy C castings.

The physical test shall be performed on coupons cast integrally with the casting, as described in ASTM B-208, double keel block test bar. The coupons shall remain attached during all heating and cooling cycles to which the casting is subjected. In cases where castings are of such a size or design that it is difficult to cast attached coupons, permission may be granted by the Engineer to cast test coupons independently of the castings.

786.3 WORKMANSHIP:

Castings shall be sound, clean, and free from blowholes, porous places, cracks, and other defects.

Castings that show injurious defects revealed by machine operations or by X-ray subsequent to delivery may be rejected and, if rejected, shall be replaced by the Contractor without charge.

No welding or patching of defects in castings will be permitted unless authorized by the Engineer. Any such welding or patching done without authorization shall be cause for rejections.

786.4 ORNAMENTAL TABLETS:

The letters shall be heavily raised and spaced carefully to secure a uniform and balanced effect over the entire area of the panel. The background of the letter panel shall have a finely-pebbled surface. The model of the tablet shall be submitted to the Engineer for approval before castings are made.

Castings shall be boldly filleted at angles, and the arises shall be sharp and perfect. Castings shall be true to pattern in form and dimension and shall be free from inclusion of foreign material, casting faults, injurious blowholes, or other defects rendering them unsuitable for the service intended.

The faces and edges of lettering and ornaments shall be carefully hand-tooled sharp and clean. Beveled edges shall be hand-tooled sharp, clean, smooth, and true. Outside borders shall be straight and true and shall be thoroughly polished. Filing and other tool marks shall be removed.

The lettering, the ornaments, and the beveled edges shall be given a fine satin hand finish; the lettering, bevels, and rosettes shall be highlighted; the leaves and scrolls slightly highlighted, but well polished. The pebble background shall be finished in dark statuary bronze, polished as the Engineer may direct.

786.5 EXPANSION AND BEARING PLATES:

The sliding contact faces shall be machined smooth to true planes. If practicable, one plate shall be machined at right angles to the other plate in the set.

GRAY IRON CASTINGS

787.1 GENERAL:

The castings shall be true to pattern in form and dimension and free from pouring faults, spongings, cracks, blowholes, or other defects in locations affecting their strength and value for the service intended. Castings shall be filleted boldly at angles, and the arises shall be sharp and true.

Before the castings are removed from the foundry, they shall be thoroughly cleaned and the parting lines, gates, and risers ground flush.

787.2 TEST SPECIMENS:

Test coupons shall be cast separately of the castings, using a mold as described in ASTM A-48. A representative of the Engineer may be present at the time a melt is poured to identify both coupons and castings.

Two test coupons are required for each melt poured. Additional coupons shall be cast for use as replacements or in case a retest is required.

A representative of the Engineer may discard and replace specimens which show obvious lack of continuity of metal or if the machining is defective.

The manufacturer shall machine the tension specimens to the dimension specified for specimen B of ASTM A-48, at no additional cost to the Contracting Agency.

When approved by the Engineer transverse tests may be made in lieu of tensile tests, in which case the castings shall meet the requirements of ASTM A-48.

787.3 MANHOLE FRAME AND COVER SETS:

Castings shall conform to ASTM A-48, Class 30. The bearing surfaces of the frames and covers shall be machined and the cover shall seat firmly onto the frame without rocking.

Covers shall be the types and shall be imprinted as shown on the plans or standard details.

Municipality	Supplements
PH:	<p>787.3 Manhole Frame and Cover Sets: add the following paragraphs:</p> <p>ASTM A-48 Class 35, gray cast iron manhole frames and covers are approved for use on City projects. The weights of the 30-inch frame and cover castings shall be a minimum of 219 pounds for the frame and 207 pounds for the cover. The weights of the 24-inch frame and cover castings shall be a minimum of 170 pounds for the frame and 180 pounds for the cover. The Contractor shall provide manufacturer's certification that the product meets the required H-20 traffic loading.</p> <p>MAG Standard Detail 424 (2411 and 3011 Manhole Frame and Cover) shall be modified to include a 3/4 inch diameter hole near the center of both the 24-inch and the 30-inch sanitary manhole covers.</p> <p>The casting shall be tested in accordance with the method and procedure that is outlined in AASHTO M306 Section 7.0, proof load testing. The casting shall be tested on a suitable and calibrated load testing machine and the casting shall hold a 40,000-pound proof load for one minute without experiencing any cracks or detrimental permanent deformation. Any added costs for testing are assumed by the manufacturer.</p> <p>A foundry certification shall be furnished to the Owner stating that the samples have been tested, inspected, and are in accordance with these specifications.</p>

787.4 RAILINGS, RAILING POSTS, AND WHEEL GUARDS:

Castings shall conform to ASTM A-48, Class 40.

787.5 ROCKERS, ROCKER PLATE BEARINGS, AND BEARING PLATES FOR BRIDGES:

Castings shall conform to ASTM A-48, Class 50.

Castings shall be machined and finished as specified on the plans provided that tool marks on sliding contact surfaces shall run in the direction of plate movement, or in the case of rocker plate bearings, perpendicular to the rocker movement. Tool marks shall be not more than 1/32 inch apart.

787.6 UNCLASSIFIED CASTINGS:

All castings not specifically classified, shall conform to the requirements of ASTM A-48, Class 30.

Municipality	Supplements
SC:	787.7 ASPHALTUM COATING: <i>Delete subsection in its entirety.</i>

PAINT

790.1 GENERAL:

Paint shall be homogeneous, free of contaminants, and of a consistency suitable for the intended use. Finished paint shall be well-ground and the pigment shall be properly dispersed in the vehicle according to the requirements of the paint; and this dispersion shall be of such nature that the pigment does not settle appreciably, does not cake or thicken in the container, or become granular or curdled. Paint and paint materials shall be delivered to the job site in new, unopened air-tight containers appropriately identified with the manufacturer's name, date of manufacture, type of paint or paint material, specifications paint number, and lot or batch number. The container shall have a formula label.

No paint shall be used until at least 7 days have elapsed from the date of manufacture. Paint containing lead shall comply with Subsection 107.5.2.

790.2 PROPRIETARY BRANDS:

For the purpose of this specification, proprietary brands of paint and paint materials shall be construed to mean paint or paint materials conforming to the requirements of this specification and produced for distribution and consumption through regular wholesale and retail outlets. Whenever paint or paint materials are designated on the plans or special provision by a manufacturer's name or catalog reference, any proprietary brand of equal quality will be permitted, subject to the approval of the Engineer. Information required by the Engineer as proof of the comparative quality shall be furnished by the Contractor.

790.3 PAINT COATS:

The first coat of paint applied to an unpainted surface shall be called the prime coat. The paint applied to field connections, welds, rivets, and all damaged or defectively painted or rusty areas on a prime coated surface shall be called a touch-up coat. The paint applied over the prime coat and touch-up coat shall be called the second coat. The final coat of paint shall be called the finish coat.

790.4 MATERIALS:

Materials shall conform in all respects to the requirements of references specifications indicated for such material.

Upon request of the Engineer, the Contractor shall furnish a certification from the manufacturer that the material conforms with this specification.

(A)	Vehicles:	Specification:
	Raw Linseed Oil	ASTM D-234
	Boiled Linseed Oil	ASTM D-260
	Water-Resistant Spar Varnish	Navy Department Specification 52V20
	Alkyd Resin	TT-R-266C
	Driers	ASTM D-600, Class A or Class B, as applicable
	Thinners:	
	Xylene	TT-X-916B, Grade A
	Turpentine (shall be used in paints used for timber)	ASTM D-13, Gum Spirits
	Petroleum Spirits (Mineral Spirits)	ASTM D-235

(B)	Pigments	Specifications:
	Carbonblack	TT-P-343 Form 1, Class B
	Lampblack	ASTM D-209
	Red Lead	ASTM D-83
	Titanium Dioxide, Non-extended	ASTM D-476, Type II, Class II
	Titanium Dioxide, Extended (Titanium Calcium, Rutile)	ASTM D-476
	Titanium Dioxide	TT-P-422B, Type III, Class A
	White Lead Basic Carbonate	ASTM D-81
	Zinc Yellow (Zinc Chromate)	ASTM D-478, Type II
	Zinc Oxide	ASTM D-79
	Iron Blue	TT-P-385
	Iron Oxide, Yellow	TT-P-458A
	Iron Oxide, Orange	ASTM D-3721, D-3722, D-3724
	Hansa Yellow G	MIL-H-10330
	Organic Green Gold	Dupont YT 562-D or equal, specific gravity 161 ±0.05
	Chromium Oxide, Green Graphite	TT-P-347

Graphite shall be natural amorphous material (American product) which shall contain not less than 35 percent nor more than 45 percent graphite carbon. The remainder shall be insoluble siliceous material containing a total of not more than 5 percent calcium and magnesium carbonate and sulfate. The pigment shall be ground to such a fineness that not less than 97 percent shall pass a No. 325 sieve. The graphite paste shall be made by grinding the pigment in pure raw linseed oil in the following proportions:

Amphorus Graphite	68.0 percent
Linseed Oil	32.0 percent

(C)	Inert Materials:	Specifications:
	Diatomaceous Silica	ASTM D-604, Type A
	Magnesium Silicate	ASTM D-605

790.5 MIXED PAINTS:

All mixed paints shall, in general, be machine-mixed and shall consist of the pigment of the required fineness and composition, ground to the desired paste consistency in pure raw or boiled linseed oil, to which shall be added the remainder of the vehicle to make paint conforming to the required formula as herein specified.

Paint which has hardened and thickened in the container such that it cannot be readily broken up to a smooth uniform paint of good brushing consistency shall not be used.

All materials used in mixed paints shall conform to the requirements as herein specified. The paint shall be made to satisfactory workable consistency conforming to one of the following formulas for paint as required on the plans or in the special provisions. All percentages shown are by weight.

Any of the following paints which are too thick to have a satisfactory workable consistency shall be thinned with a suitable thinner from the group of thinners herein specified. In no case shall gasoline be used as a thinner.

Fineness of grind for enamel shall conform to Hegman 7 minimum.

The following paints shall conform to the latest ADOT standard specifications for Road and Bridge Construction. All paints, except Paint No. 10 (Aluminum), shall be shipped ready for use.

When Paint No. 1 is specified, it may be Paint No. 1-A or Paint No. 1-B. Paint No. 1-D shall be used only when specifically designated.

Paint Number

1-A

1-B

1-D

4

5

6

7

8

9

10

11

15

Type

(Red Lead — Linseed Oil)

(Red Lead — Alkyd Resin)

(Zinc Chromate)

(Dull Black)

(Jet Black)

(Black — For Timber Primer Only)

(White — For Timber Primer Only)

(White)

(Light Grey)

(Aluminum)

(White Enamel)

(Zinc)

DUST PALLIATIVE

792.1 GENERAL:

Dust palliatives shall consist of various chemical dust suppressants which work by binding together lighter soil particles.

All materials must meet the environmental requirements of Section 792.3 and must be approved by the Engineer prior to their use.

792.2 TYPE OF MATERIALS AND APPLICATION RATES:

Emulsions shall be miscible with water in all proportions as noted in Table 792-1. The dilution ratio will vary based upon the local soil and weather conditions. The ratios shall be proposed by the Contractor and agreed upon by the Engineer.

The rate of application noted in Table 792-1 shall be for the treatment, method and use specified by the Contracting Agency, or as directed by the Engineer. To compensate for local conditions, the Contractor may adjust the application rate within the ranges specified.

Products specifically formulated as tackifiers which prevent wind-blown erosion shall not be acceptable as dust palliatives for vehicular traffic, but may be used for their intended purposes.

TABLE 792-1				
DUST PALLIATIVE DILUTION RATIOS AND APPLICATION RATES				
Product Type	Use/Treatment ⁽¹⁾	Dilution Ratio ⁽²⁾		Application Rate ⁽³⁾ (gal/sy) [l/m ²]
		Range	Typical	
Acrylic Copolymer	Topical - Road or parking Lot	20:1 to 4:1	9:1	0.20 to 0.10
	Topical - Road Shoulder	20:1 to 4:1	15:1	0.16 to 0.09
	Surface Course (per inch of depth)	20:1 to 4:1	9:1	0.10 to 0.06
Petroleum Resin Emulsified	Topical - Road or parking Lot	4:1	4:1	0.15 to 0.10
	Topical - Road Shoulder	10:1 to 7:1	8:1	0.15 to 0.07
	Surface Course (per inch of depth)	4:1	4:1	0.11 to 0.07
Lignin-Based Type (Lignosulfonate)	Topical - Road or parking Lot	1:1	1:1	0.10 to 0.05
	Topical - Road Shoulder	7:1 to 4:1	4:1	0.05 to 0.03
	Surface Course (per inch of depth)	1:1	1:1	0.30 to 0.10
Organic Resin	Topical - All	10:1 to 2:1	5:1	0.25 to 0.15
	Surface Course (per inch of depth)	2:1 to 1:1	1:1	0.15 to 0.10
Other	As approved by the Engineer			

(1) Topical application rates shown are to obtain 1/2 to 1 inch penetration. Higher rates should be used if greater penetration is anticipated.

(2) The dilution ratio (water:product) is variable and shall be appropriate for the local soil and weather conditions, as proposed by the Contractor and agreed upon by the Engineer.

(3) Application rate of undiluted concentrate.

(A) Acrylic Copolymer Types:

The material shall be a white or clear emulsion that can penetrate, saturate and bond together treated soils to create a hard, dust-free and water resistant surface. The material shall have the following properties in its undiluted state:

Specification Designation	ASTM Test Method	Requirements
Composition	—	Acrylics, acrylates & acetates
pH	E 70	4.0 - 9.5
Residue (active solids content), %	D 244	40 min.
Flash Point, °F	D 92	None
Absolute Viscosity (Brookfield), cP, 77 °F.	—	1500 max.
Specific Gravity, 60/60 °F.	D 1298	1.00 - 1.15

(B) Petroleum Resin Emulsified Types:

The materials shall be a light yellow petroleum resinous emulsion suitable for use as an agglomerate for soil particles. The material shall have the following properties in its undiluted emulsified state:

Specification Designation	ASTM Test Method	Requirements
Kinematic Viscosity, SFS at 77 °F.	D 244	15 min.
pH	E 70	4.0 - 7.0
Residue, % wt. (1)	D 244	64±4
Sieve Test, % wt. Retained (2)	D 244	0.1 max.
Particle Charge Test	D 244	Positive
Flash Point of base product, CO, °F.	D 92	400 °F. min.
Specific Gravity of base product, 60/60°F.	D 1298	1.00 to 1.04

(1) ASTM test modified by heating 50 g of sample to 300 °F. until foaming ceases, then cooling immediately and calculation results.

(2) Replace 2% sodium oleate solution with distilled water in test.

The emulsion shall be stable, i.e., should not break when stored in clean closed containers at temperatures between 35°F. and 200 °F. for a minimum of 3 months. The sequestering agents shall make the preparation stable against hard water, thus permitting dilution of the emulsion with almost all types of water. The emulsion shall be non-corrosive to metal containers. The materials shall penetrate into the soil and not form a skin at the surface or a crusted surface.

(C) Lignin-Based Types:

Lignin-based dust palliative shall be an aqueous lignosulfonates (a residual co-product of wood pulping by the sulfite process in the manufacturer of cellulose products) that dispersed readily in water to yield a stable, brown-colored solution. The material shall have the following properties in its undiluted state:

Specification Designation	ASTM Test Method	Requirements
Absolute Viscosity (Brookfield), cP, 77°F.	—	< 1,000
Residue (total solids content), %	D 244	48 min.
Lignin sulfonate content (% of solids)	D 244	60 min.
pH	E 70	5.0 - 7.0
Specific Gravity (liquid), 77/60°F.	D 1298	1.00 min.

(D) Organic Resinous Types:

The material shall be a tan emulsion designed specifically for dust control of unpaved roads, traffic surfaces, and road shoulders that utilizes non-petroleum based organic esters and resins combined with other additives to penetrate, bond and coat treated soils. The material shall have the following properties in its undiluted state:

Specification Designation	Test Method	ASTM Requirements
Absolute Viscosity (Brookfield), cP, 77°F	—	50 - 200
PH	E 70	3.0 - 9.0
Residue (active solids content), %	D 244	45 min
Flash Point	D 92	None
Specific Gravity, 60/60°F	D 1298	1.00 min.

(E) Other Types:

Other types of dust palliative may be approved for use by the Engineer. Test methods, requirements, dilution ratios and application rates shall be as specified by the manufacturer.

Municipality	Supplements
PH:	792.2 TYPE AND APPLICATION OF MATERIAL: Paragraph (A) Asphalt Base Type: Delete this paragraph in its entirety. These asphalt base dust palliatives are not available or are restricted from use as dust palliatives.

792.3 ENVIRONMENTAL CRITERIA:

Products shall not contain or emit chlorinated fluorocarbons (CFS's Freon's) and shall not contain or emit volatile organic compounds (VOC's) that exceed Federal, State or Local air quality limitations.

Products and their degradation products shall not be composed of elements, compounds, mixtures or produce runoffs with the characteristics identified under Arizona Revised Statutes 36-2822 of the Arizona Hazardous Waste Management Act, emit or off-gas during placement, use or degradation of any hazardous air pollutant listed under Section 112 of the Federal Clean Air Act [42 U.S.C. § 7412], be a hazardous chemical substance or mixture pursuant to Section 7 of the Federal Toxic Substances Control Act [15 U.S.C. § 2606], be designated by rule an extremely hazardous chemical substance pursuant to the Arizona Environmental Quality Act, produce runoffs that contain concentrations exceeding the parameters designated in Section 2.18 'Table 5' of the National Pollutant Discharge Elimination System (NPDES) Multi-Sector General Permit for Industrial Activities (see Note A), be prohibited for use by the Arizona Department of Environmental Quality, the Environmental Protection Agency, or any applicable law, rule or regulation.

Products or their components and degradation products shall be tested and certified by the manufacturer not to be substances or composed of substances known to be, or reasonably anticipated to be carcinogenic or toxic by the U.S. Department of Health and Human Services.

Products must have hazardous Materials Identification System (HMIS) ratings equal to or less than the following for each category: H=1; F=1; R=1; PPE=X.

Note A: Parameter benchmark values shall be provided by the Engineer and based on the Contracting Agency's requirements.

LANDSCAPE MATERIAL

795.1 GENERAL:

Material used for landscaping purposes shall be in conformance with this Section.

The common and scientific names of plants shall conform to the approved names in Standard Plants Names (SPN) or its successor, American Association of Nurserymen (ASN). For identification and inspection, durable, legible labels, bearing the plant's name in water-resistant ink, shall be attached to all nursery stock or container of stock delivered to the project site.

Municipality	Supplements
PH:	795.1 GENERAL: Material used for landscaping purposes shall be in conformance with this section.

795.2 TOPSOIL:

Topsoil shall be a fertile, friable soil, obtained from well-drained arable land, and shall be free from nut grass, refuse, roots, heavy clay, clods, noxious weeds or any other material toxic to plant growth. At least 10 days prior to delivery of topsoil to the site, the Contractor shall furnish the Engineer at no additional cost, with a soil sample from each source for analysis and tests.

To be acceptable the pH factor shall not exceed 8.0 or be lower than 5.5, soluble salts shall not exceed 1500 PPM, the plasticity index shall be in the range of 3 and 15 inclusive, and it shall contain approximately 1 1/2%, by dry weight, or organic matter either natural or added. Gradation shall be in accordance with the following:

Sieve Size	Percent Passing
1 inch	100
1/2 inch	95-100
No. 4	90-100
No. 10	70-100
No. 200	15-70

Municipality	Supplements										
PH:	795.2 TOPSOIL: Topsoil shall be a fertile, friable soil, obtained from well-drained arable land, and shall be free from nut grass, refuse, roots, heavy clay, clods, weed seed or any other material toxic to plant growth. At least 10 days prior to delivery of topsoil to the site, the Contractor shall furnish the Engineer, at no additional cost, with a soil sample from each source for analysis and tests. Soil tests will be accomplished by an approved independent soil testing laboratory capable of doing the appropriate horticultural soil test. The results of the test will determine the acceptability of the soil. The testing laboratory may suggest ways to amend the soil to make it suitable to grow plants. The Contractor may be directed by the Engineer to provide the amendments at no additional cost. To be acceptable, the pH factor shall not exceed 8.0 or be lower than 5.5, soluble salts shall not exceed 1500 PPM, the plasticity index shall be in the range of 3 and 10 inclusive, and it shall contain between 1 and 2%, by dry weight, organic matter either natural or added. Gradation shall be as follows: <table> <tr> <td>Sieve Size</td><td>Percent Passing</td></tr> <tr> <td>1/2"</td><td>100</td></tr> <tr> <td>No. 4</td><td>90 - 100</td></tr> <tr> <td>No. 10</td><td>70 - 100</td></tr> <tr> <td>No. 200</td><td>15 - 70</td></tr> </table>	Sieve Size	Percent Passing	1/2"	100	No. 4	90 - 100	No. 10	70 - 100	No. 200	15 - 70
Sieve Size	Percent Passing										
1/2"	100										
No. 4	90 - 100										
No. 10	70 - 100										
No. 200	15 - 70										

795.3 SOIL FERTILIZING MATERIAL:

Fertilizing material shall comply with the applicable requirements of the State Agricultural Code. All fertilizing material shall be packaged, first grade, commercial quality products identified as to source, type of material, weight and manufacturer's guarantee analysis. It shall not contain toxic ingredients or fillers in quantities harmful to human life, animals or plants. It shall be delivered in unopened containers and shall have the chemical analysis as specified in the plans or specifications. Material which has become caked or otherwise damaged shall not be used.

Municipality	Supplements														
PH:	<p>795.3 SOIL AMENDMENTS AND CONDITIONERS:</p> <p>795.3.1 Chemical Conditioners: Fertilizing material shall comply with the applicable requirements of the State Agricultural Code. Fertilizing material shall be packaged, first grade, commercial quality products identified as to source, type of material, weight and manufacturer's analysis. It shall not contain toxic ingredients or fillers in quantities harmful to human life, animals, or plants. Material which has become caked or otherwise damaged shall not be used.</p> <p>Fertilizing material for plants shall be similar to the product "Super Start" or approved equal, with the following additive ingredients (% by weight): 3% Nitrogen, 10% Sulfur, 4% Iron, 1% Zinc, 0.08% Manganese, and 0.13% Viterra. All fertilizing material shall be in 40 pound packages with additive ingredient derived from:</p> <ol style="list-style-type: none"> 1. Nitrogen from Urea Formaldehyde and M.A.P. 2. Sulfur from Potassium Sulfate 3. Iron from Sequestrene 138 Iron 4. Zinc from Sequestrene Zinc 5. Manganese from Sequestrene Manganese 6. Viterra from a synthetic, superabsorbent co-polymer. <p>Slow Release Fertilizer Plant Tablets: Shall be Agriform 21 gram tablets or equal with 20-10-5 analysis.</p> <p>Fertilizing Material for lawn areas or used in revegetation shall be a commercially approved brand or a mixture of standard commercial forms to meet the requirements recommended by horticultural test results.</p> <p>Slow Release Nitrogen: Shall be Methylene urea (38-0-0) or equivalent. It is use to extend nitrogen availability over time on sites where long term nitrogen availability is a limiting factor.</p> <p>795.3.2 Organic Soil Amendments:</p> <p>General Soil Conditioner: Compost shall be naturally organic, free of weeds and weed seeds, and contain no plant growth inhibiting factors. This material shall be tested and meet the following minimum requirements.</p> <table border="0" style="width: 100%;"> <tr> <td>Germination Rate (full strength extract)</td><td style="text-align: right;">85% minimum</td></tr> <tr> <td>Maturity Index (full strength extract)</td><td style="text-align: right;">50% minimum</td></tr> <tr> <td>Conductivity EC mmhos/cm</td><td style="text-align: right;">less than 8</td></tr> <tr> <td>Exchangeable Sodium Percentage</td><td style="text-align: right;">less than 15</td></tr> <tr> <td>Carbon/Nitrogen Ratio</td><td style="text-align: right;">less than 20:1</td></tr> <tr> <td>Total Nitrogen (not added)</td><td style="text-align: right;">0.5% minimum</td></tr> <tr> <td>pH range of extract</td><td style="text-align: right;">5.5 – 8.0</td></tr> </table> <p>When cow manure is used as a soil conditioner in turf areas, it shall be the product of yard fed cattle, free of weed seeds, straw or any other inert material and aged at least 3 months. This manure shall have been processed by grinding and screening and shall be treated with a non-toxic agent so as to be hydrophilic.</p> <p>Plant Conditioner: Shall consist of a ground or processed wood product derived from redwood, ground or</p>	Germination Rate (full strength extract)	85% minimum	Maturity Index (full strength extract)	50% minimum	Conductivity EC mmhos/cm	less than 8	Exchangeable Sodium Percentage	less than 15	Carbon/Nitrogen Ratio	less than 20:1	Total Nitrogen (not added)	0.5% minimum	pH range of extract	5.5 – 8.0
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Exchangeable Sodium Percentage	less than 15														
Carbon/Nitrogen Ratio	less than 20:1														
Total Nitrogen (not added)	0.5% minimum														
pH range of extract	5.5 – 8.0														

	<p>shredded fir, redwood or ponderosa bark. It shall have a nitrogen content of 1%, a ph not exceeding 7.5% and organic matter not less than 85%. Mulch gradation shall be treated with a non-toxic agent so as to be hydrophilic. Cow Manure shall not be used as organic mulch in plant backfill mixes.</p> <p>Bone Meal: Commercial grade product uniform in composition.</p> <p>Sand: Shall be brown washed natural mortar sand passing at least a #7 screen, free of weeds, organic material, stones, deleterious materials, non-toxic to plant and human life and usable for backfill mixtures.</p> <p>Hydromulch shall be packaged in units containing current labels, with the manufacturer's name, the net weight, and certification that the material meets the forgoing requirements. The mulch shall be dyed green to aid in the visual metering application. The dye shall be biodegradable and not inhibit plant growth.</p> <p>1.) 100% Wood Cellulose Fiber Hydromulch: Shall be shall be used as mulch when hydroseeding turf grass.</p> <table> <tr> <td>Moisture content</td><td>10.0% + 3.0%</td></tr> <tr> <td>Organic Matter (Wood Cellulose Fiber). . .</td><td>99.3% + 0.2%</td></tr> <tr> <td>Ash content</td><td>0.7% + 0.5%</td></tr> <tr> <td>PH</td><td>4.9 + 0.5%</td></tr> <tr> <td>Water Holding Capacity</td><td>10 : 1</td></tr> </table> <p>2.) Cellulose Fiber Hydromulch: Shall be used as mulch when hydroseeding native seed. Cellulose fiber mulch shall consist of at least 70% specially prepared virgin wood cellulose fiber which has been thermo-mechanically processed for specific use as hydromulch. It shall contain no growth inhibiting factors. It shall have the following properties:</p> <table> <tr> <td>Wood Cellulose Fiber</td><td>70% (minimum)</td></tr> <tr> <td>Recycled Cellulose Fiber</td><td>30% (maximum)</td></tr> <tr> <td>Ash Content.</td><td>0.8% \pm 0.3% (maximum)</td></tr> <tr> <td>pH</td><td>4.5 \pm 1.0</td></tr> <tr> <td>Water Holding Capacity ratio; water : fiber.</td><td>10 : 1</td></tr> </table> <p>Upon application, the mulch material shall form a blotter-like mat covering the ground. This mat shall have the characteristics of moisture absorption and percolation and shall cover and hold seed in contact with the soil.</p> <p>Tackifier: Used in hydroseeding shall consist of a free-flowing, noncorrosive powder produced from the natural plant gum of <i>Plantago insularis</i> (Desert Indianwheat), applied in a slurry with water and wood fiber. The powder shall possess the following properties:</p> <table> <tr> <td>Protein content</td><td>1.6 + 0.2 %</td></tr> <tr> <td>Ash content</td><td>2.7 + 0.2%</td></tr> <tr> <td>Fiber</td><td>4.0 + 0.4%</td></tr> <tr> <td>pH 1% solution</td><td>6.5 –8.0 %</td></tr> </table> <p>The material used for mulch tackifier shall not contain any mineral filler, recycled cellulose fiber, clays, or other substance which may inhibit germination or growth of plants.</p> <p>Activated Charcoal: Agricultural grade powdered activated charcoal is used in the hydromulching slurry to boost seed germination during cold weather as a soil colorant.</p> <p>Granular humus based soil conditioner used in hydromulching operations shall be tested and meet the following:</p> <table> <tr> <td>Total humus</td><td>50% minimum</td></tr> <tr> <td>Total humic acid</td><td>15% minimum</td></tr> </table> <p>Liquid humic acid soil based conditioner used in hydromulching operations shall be tested and meet the following:</p> <table> <tr> <td>Total humic acid</td><td>6% minimum</td></tr> </table>	Moisture content	10.0% + 3.0%	Organic Matter (Wood Cellulose Fiber). . .	99.3% + 0.2%	Ash content	0.7% + 0.5%	PH	4.9 + 0.5%	Water Holding Capacity	10 : 1	Wood Cellulose Fiber	70% (minimum)	Recycled Cellulose Fiber	30% (maximum)	Ash Content.	0.8% \pm 0.3% (maximum)	pH	4.5 \pm 1.0	Water Holding Capacity ratio; water : fiber.	10 : 1	Protein content	1.6 + 0.2 %	Ash content	2.7 + 0.2%	Fiber	4.0 + 0.4%	pH 1% solution	6.5 –8.0 %	Total humus	50% minimum	Total humic acid	15% minimum	Total humic acid	6% minimum
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Total humus	50% minimum																																		
Total humic acid	15% minimum																																		
Total humic acid	6% minimum																																		

795.4 ORGANIC SOIL CONDITIONERS:

In general, soil conditioners shall consist of a ground or processed wood product derived from redwood, ground or shredded fir, redwood or ponderosa bark. It shall have a nitrogen content of 1%, a pH not exceeding 7.5, and organic matter not less than 85%. Its gradation shall be such that at least 85% passes the 1/4 inch screen. In addition, it shall be treated with a non-toxic agent so as to be hygroscopic.

When manure is used as a soil conditioner, it shall be the product of yard fed cattle, free of weed seeds, straw or any other inert material and aged at least 3 months. This manure shall have been processed by grinding and screening and shall be of a consistency that will readily spread with a mechanical spreader.

795.5 CHEMICAL SOIL CONDITIONER:

Chemical soil conditioners such as soil sulfur, gypsum or iron additive shall be commercially approved brands designated for agricultural use. Material which has become caked or otherwise damaged shall not be used.

795.6 SEEDS:

Seeds shall be fresh, clean seeds, pre-mixed to the specified proportion. They shall be delivered to the site in original, unopened containers bearing the dealer's guaranteed analysis and germination percentage. They shall have a certificate or a stamp or a release accomplished by an agricultural commission.

Municipality	Supplements
PH:	<p>795.3 SEEDS:</p> <p>795.3.1 Native Seeds: Shall be certified to scientific name, lot number or other identification, origin of the seed, purity of the seeds as a percentage of pure live seed by weight, germination percentage and percentage of firm ungerminated seeds, name and address of person who labeled or offers seed for sale.</p> <p>Pure Live Seed (PLS) percentage = (% germination + % ungerminated firm seed) x (% purity). The seed rate specified is pounds of Pure Live Seed.</p> <p>795.3.2 Turf seed shall be fresh clean seeds, pre-mixed to the specified proportion. They shall be delivered to the site in original, unopened containers bearing the dealer's name guaranteed analysis and germination percentage. They shall have a certification or a stamp or a release accomplished by an agricultural commission.</p>

795.7 PLANTS, TREES, AND SHRUBS:

795.7.1 General: All landscape stock shall be grown in nurseries approved by the State Department of Agriculture. They shall have a growth habit normal to the specie. Stock shall be sound, healthy, and vigorous; free from insect pests, sun scald, excessive bark abrasions and other objectionable disfigurements. They shall have normal, well-developed branch systems and vigorous, fibrous root systems which are neither root nor pot-bound and are free of kinkled or girdling roots.

All stock shall have been grown in pots, cans, tubs, or boxes for a minimum of three months and a maximum of one year. They shall have sufficient roots to hold earth together after removal from the containers. This earth shall be free from noxious weeds including bermuda grass.

Stock shall be inspected and approved by the Engineer at the Contractor's storage site prior to delivery to the project.

795.7.2 Flatted Plants: Flatted plants shall be grown and remain in the flats until transported to the project site. The soil and spacing of the plants in the flats shall insure the minimum disturbance of the root system at transplanting.

Municipality	Supplements
PH:	<p>795.3 Plants:</p> <p>Plants shall be nursery grown or plantation grown stock conforming to ANSI 260-1 and shall be of the varieties specified in the plant list bearing botanical name listed. Plants shall meet the standards established by the Arizona Nursery Association Grower's Committee recommended specifications.</p> <p>Planting stock shall be well broached and well formed, sound, vigorous, healthy and free from disease, sun-scald, windburn, abrasion and harmful insects or insect eggs and shall have healthy, normal and unbroken root system which is neither root or pot-bound and are free of kinked or girdling roots. Plants shall have been grown under climate conditions similar to those at the project site.</p>

Municipality	Supplements
PH:	<p>795.3 Sod:</p> <p>Shall be Midiron Bermuda if not specified on the plans and meet State standards to insure high quality and freedom from noxious weeds.</p> <p>Sod shall be machine cut at a uniform soil thickness of 1/2 inch (plus or minus 1/4 inch), at time of cutting. Measurement excludes top growth and thatch.</p> <p>Standard size sections of sod shall be strong enough to support their own weight and retain their size and shape when suspended vertically from a firm grasp on the upper 30% of the section.</p> <p>Sod shall be free from disease, nematodes, and soil born insects.</p>

Municipality	Supplements
PH:	<p>795.6 MISCELLANEOUS MATERIAL:</p> <p>795.6.1 Lumber: Lumber in contact with the earth shall be redwood heartwood, sized according to the drawing. When unit bid items that include headers or lumber are included in the proposal sheets, the unit prices quoted shall be per linear foot.</p> <p>795.6.5 Clean fill: Clean fill shall be soil free of weeds, boulders, clods, heavy clay, aggregate base, asphalt or concrete or other deleterious material.</p> <p>795.6.6 River Run Rock: Rock shall be clean, hard, durable, uniform in quality, free from seams and coatings, rounded and water-worn. The gradation shall be as specified and approved by the Engineer.</p>

795.7.3 Trees: Trees shall be of the specified height, spread and caliper and shall stand erect without support. The height shall be measured from the root crown to the last division of the terminal leader with the branches in a normal position and the caliper shall be measured 12 inches above the crown roots. For palm trees only, the height shall be measured from the ground line to the base of the growing bud.

795.7.4 Shrubs: Shrubs shall be of the specified type, height and spread. They shall be selected from high quality, well-shaped nursery stock.

795.8 MISCELLANEOUS MATERIAL:

795.8.1 Headers and Stakes: Lumber for landscaping shall be construction heart, rough-sawn redwood in the sizes specified; splicing will not be permitted. Stake used with header boards shall be 2 x 4 inches, pointed and at least 18 inches long.

795.8.2 Tree Stakes: Unless otherwise specified, tree stakes shall be 2 x 2 inch redwood posts, free of knots and reasonably straight, and of sufficient length to properly support the tree.

795.8.3 Tie Wires: Tie wire shall be No. 12 AWG zinc coated wire and the cover for this wire shall be 1/2 inch garden hose.

795.8.4 Decomposed Granite: Decomposed granite shall be as per Subsection 702.4 with the following exceptions. All material used for a specific project or location shall be from a single source and shall present a uniform appearance. The gradation shall be as shown below. If a specific color or type is required, it will be so indicated in the Contracting Agency's specifications.

Sieve Size	Percent Passing
3/4 inch	100%
1/2 inch	60-70
No. 40	5-20

